THE HUMAN·BODY AND·ITS·ENEMIES

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PREFACE.

An examination of school physiologies published within the last four or five decades discloses the changing viewpoints of teachers of this subject. First anatomy was stressed, then physiology became prominent, while in recent years leaders in educational thought are agreed that hygiene is of paramount importance. Within this recent period there has been a shifting of accent from dress and diet to the prevention of germ diseases. The most generally accepted course of today for elementary "physiology" is one that does not minimize any of the phases of the subject mentioned, but one that preserves a correct proportion among them.

The essential principle of hygiene has ever been cleanliness. The race has developed an instinctive horror for the unclean. Since the discovery of micro-organisms as the causative agents of disease, however, our adherence to cleanliness has become specific and intelligent. There are, for example, many harmless substances far more revolting than human blood containing malarial parasites. But modern hygiene teaches that the blood of a malarial patient, taken in conjunction with a certain species of mosquito, makes a combination which is, from a health standpoint, very "unclean."

There is, therefore, a well-founded demand that children be taught the essentials of germ diseases and their prevention. The authors of the present volume have placed this material first, believing that its importance justifies this order of treatment.

There is in some quarters a timidity in dealing with these topics of health and disease on the ground that increased knowledge along these lines would lead to a more pessimistic point

of view. The important role of optimism in the preservation of health is well recognized. Yet, in view of our present knowledge of the wonderful defenses of the human body, it must be conceded that an understanding of them gives an increased confidence and renewed optimism based on fact and not merely on sentiment.

A discussion of the anatomy of the human body has been reduced to a minimum; likewise, the physiology has been subordinated to the principles of hygiene. Such a treatment is believed to appeal to the reason of the child, for persuasion is more effective than arbitrary command.

The fact has been borne in mind that "physiology and hygiene" is practically the only natural science that the great bulk of our people ever have an opportunity of studying. The scientific treatment has, therefore, been adhered to as closely as the intellectual advancement of the pupil for whom this work is intended would seem to allow.

Aids to the memory, however, have not been omitted. A summary of the important points together with carefully selected questions at the end of each chapter will be found of help to the pupil in his study. Frequent review questions and cross references in the text afford ample opportunities for repetition.

Experience in teaching science soon convinces one that poor thinking is largely due to vague mental concepts of things and relations. The laboratory method of "seeing for one's self" has been stressed in these pages. The numerous experiments introduced throughout the book are all simple and can be performed easily and with very little outlay for apparatus and material.

Illustrations are today considered a necessity in a modern scientific book, particularly in one intended for the young mind.

This book contains more illustrations than any book of its kind that has come under our notice. With several exceptions, they were all drawn expressly for this book. For many of the illustrations a distinct pedagogical value is claimed, particularly the types of illustrations exemplified by the section of the skin (Fig. 176, shown in three dimensions) and by the figures of bone tissue (Figs. 189-191).

The authors' grateful acknowledgments of thanks and appreciation are due their many friends of the teaching and medical profession in Texas and other States for kind assistance and suggestions in the preparation of this work.

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Austin, Texas, Aug. 1, 1912.

CHAPTER I.

Introduction.

If it were your duty to care for and operate some fine piece of machinery, like an automobile, you would first want to know a great deal about the machine, its various parts, how they were put together, and how all parts worked in harmony to make the machine go. No doubt you know boys who would delight in taking an automobile to pieces and putting it together again. We always take pleasure in observing and understanding a beautiful machine, such as a watch, an aeroplane, or an automobile.

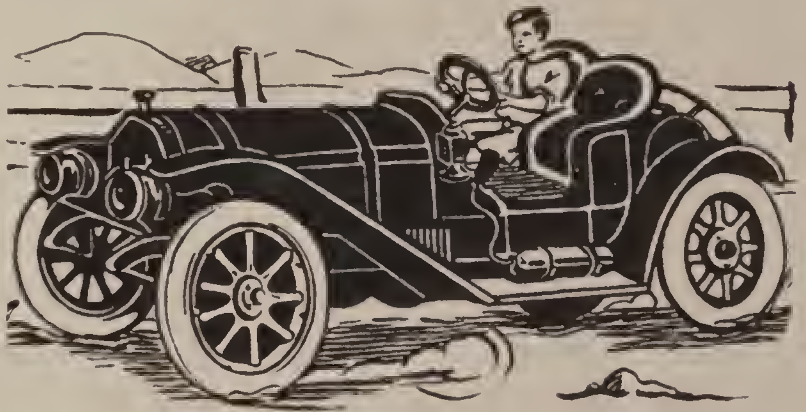

Fig. 1. The driver of an automobile should study his machine.

The Human Body is a Wonderful Machine.—Now, it is the duty of each and every one of us to care for and operate a much finer machine than any of those mentioned, and that is the human body. Did you ever stop to think what a wonderful machine your body is? Think of the brain, with which we know and remember things, feel emotions, and control our acts. Consider the eye, which is a little camera with sensitive film and focussing apparatus. How wonderfully all the parts of the body are connected by the nerves, which act as telegraph wires, carrying messages from the various parts to the brain, which is like the central office. Most wonderful of all,

consider how the food we eat becomes a part of ourselves. We must conclude then that the human body is the most marvellous machine in existence. If we are to operate this marvellous machine we certainly should understand something about it, in order that we may take proper care of it and see that it does its work properly.

Fig. 2. The aviator's life depends on his mastery over his machine.

We Must Learn What Dangers Threaten Our Bodies.—The driver of an automobile, however, must know more than the parts of his machine; he must know also what kind of dangers are to be met in the road which he is to travel. He must know the whereabouts of cactus thorns, sharp stones, and deep sands, in order that he may avoid them. Just so, the driver of the human automobile must know what dangers beset him on his life-journey. The habit of drinking alcohol, for instance, is one danger that besets some of us. Impure foods are very harmful to the body, and they are one of the dangers that may befall any of us. One of the commonest dangers, however, that lurks along our life-journey is disease or sickness due to germs.

Fig. 3. A Camera.

Disease germs not only cause more than one-third of all deaths that occur in this State, but also cause most of the blindness and a large part of the illness which afflicts our citizens. And yet, we can not be harmed by disease germs unless the germs enter our system. In order, then, to protect

ourselves against these little germ-enemies, we must study them, learn where they come from, and how they gain entrance into the human body. We shall then be in a position to avoid them, and thus steer our human automobile clear of this danger.

If we understand our bodies, and also understand just what dangers threaten us and how to avoid them, we shall be more likely to succeed in keeping ourselves in that pleasant condition which we call health.

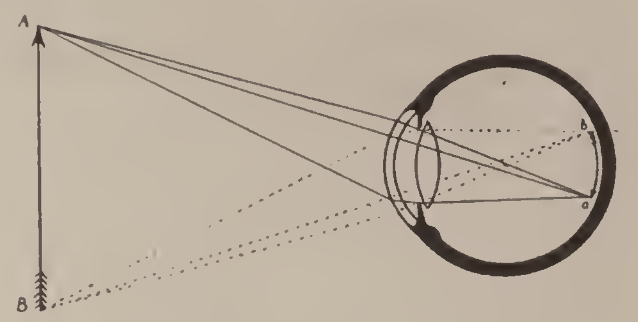

Fig. 4. The eye, a human camera.

Important Points.

1. The human body is more complex than any machine or instrument made by man.

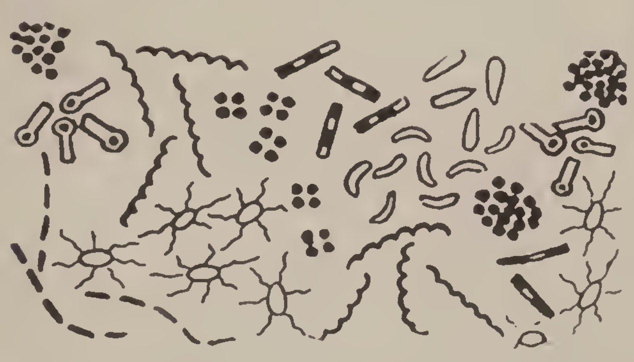

Fig. 5. A few of our germ enemies.

2. We should understand this machine in order to keep its various parts in order.

3. We should also know how best to avoid certain dangers which threaten us, such as typhoid fever, tuberculosis or consumption and other diseases due to germs.

Questions

1. Why should we study the human body? 2. Name some things which can injure the body. 3. Name one important cause of blindness. 4. What percentage or proportion of all deaths in Texas is due to germs? 5. Name several things we should know about disease germs in order to avoid them.

CHAPTER II.

Bacteria or Germs.

I should hate to have to tell you in a single sentence what germs or bacteria are. Bacteria are such wonderful little beings, and are so different from the creatures that we know, that it is very hard to get an idea of what they really are. All of you have read in the fairy tales about certain fairies that were invisible. The story of bacteria is like a fairy tale, because for many centuries we were surrounded by bacteria, and yet they were invisible to us, and in fact we never guessed or dreamed that they existed until long after Columbus discovered America. And bacteria are invisible to this day, unless we use a microscope to aid the human eye, or unless we take a great many of the bacteria in a clump to look at.

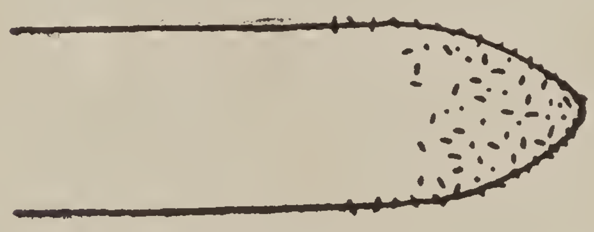

Fig. 7. This shows how much smaller bacteria are than the finest cambric needle.

Size of Bacteria.—To begin with, then, bacteria are very small. If you took a colony of them and picked it out with a needle till you had little pieces that you could barely see with the naked eye, each one of these little pieces would contain hundreds and probably thousands of bacteria. Many of them are so small that it would take twenty-five thousand of them placed side by side to occupy the space of an inch. And as small as they are, each one has a definite shape. There are three varieties of bacteria from a standpoint of shape, the rods, the round ones and the spirals. You can see these in Fig. 6.

Motion of Bacteria.—Some of them can swim about from one place to another, and others never move unless they are washed about or jostled in the fluid they live in. Those that move, either do so by squirming along like a snake swimming, or else they have little tiny hairs growing all over their bodies and whip the water with these hairs. Of course the perfectly round ones cannot do any squirming, and unless they have little hairs on them they cannot move.

Fig. 8.—The rod-shaped germs cannot move about rapidly like the ones with the little lashes on them.

Food of Bacteria.—The bacterium (for this is the word we use in speaking of a single one) has to have food, and many of them have to have oxygen just as we do. But he is so small that the food can soak in from the outside, and he does not need any mouth. Practically all of his active life is spent in a liquid, and the food simply dissolves in the liquid and passes through his very thin skin into his inside. For you know the entire bacterium isn't nearly so thick as a sheet of tissue paper, and his skin must be really so thin that we cannot realize its true thinness. But some bacteria (here we use the plural word again) seem to secrete a juice of some kind that digests meat. The only difference between their digestion and ours however, is that they pour the juice over the meat or other food while it is still outside their bodies. They let the digestion occur outside their bodies, and then absorb or soak up the food in a liquid form.

Toxins.—The bacterium is so small that he needs no kidneys. Whatever of waste matter there is in his body can soak out, or ooze out, just as his food soaks in. And this is one way

that some bacteria injure us. Some kinds of bacteria live in our bodies and pour out or ooze out their waste material in our bodies. If the waste material they pour out is poisonous to us, they make us sick. The poisonous material is called **toxin,** which means "poison." Other bacteria form a waste material is called toxin, which means not make us sick unless they multiply fast enough to stop up some passage way in the body.

Fig. 9. This glass tube contains bacteria growing on gelatine.

Multiplication of Bacteria.—And bacteria can multiply very rapidly indeed. They seem to multiply by simply dividing in two. Each one splits half in two and you have two bacteria where only one bacterium was in the first place. Starting with one bacterium, we may have many millions in a day or two.

Ultra-Microscopic Bacteria.—In studying bacteria we must not lose sight of the fact that there are some bacteria too small to be seen even with a good microscope. No one has ever seen these germs. You may well ask how then do we know that they exist. We know only from their effects. For instance, we know that foot and mouth disease in cattle is caused by a germ, and the blood of an animal sick of this disease, if injected into another animal, will cause that animal to catch the disease. Even if we filter the blood from the sick animal, so as to remove all particles large enough for us to see with the best microscope, it will still cause foot and mouth disease when injected into an animal. Our filters are fine enough to strain out all germs that are visible, and since the filtered blood still causes the disease, we must conclude that there are invisible germs in it. These germs are so small that

they pass easily through the filter and set up foot and mouth disease as soon as they reach their natural living place, which is the body of the cow. Possibly some intelligent pupil at present busy in one of our schools may some day invent a microscope powerful enough to reveal these ultra-microscopic bacteria to our sight.

At this time we tend to look on smallpox, yellow fever, measles and infantile paralysis as being due to small bacteria, which we call ultra-microscopic. Certain diseases which attack the lower animals have been proven beyond a doubt to be due to the ultra-microscopic germs.

Where Bacteria Live.—We have said nothing yet about where the bacteria live. They live almost everywhere. They live in water, they live in milk, they live in the ground, they live in dust, they live in decaying fruits, and we might say they live everywhere, except where they have been removed in some way. The most important place they live is in certain parts of our bodies. There are some harmless bacteria always present in the mouth. There are a great many harmless bacteria always present in the intestines. Some harmless varieties are in the skin, especially the outer horny layer, at all times. Certain kinds of bacteria cause milk to sour. Certain other kinds cause milk to curdle into cheese. Still other bacteria live on the roots of clover and peas and enrich the soil.

Harmless Germs and Disease Germs.—There are thousands of different kinds of bacteria, and probably not over a hundred different kinds that are harmful to man. There are some bacteria that do not multiply anywhere except in the human body, and which make poisons or toxins which make us sick or even kill us. These bacteria are dangerous. Typhoid fever, meningitis, tuberculosis, la grippe and diphtheria are all caused by bacteria. The bacteria are visible with the micro-

scope, but are so small that they could not harm us except for the poisons which they make in our bodies.

Disease Germs Multiply Only in the Body.—It is very important to remember that most of the bacteria which cause disease cannot live more than a few weeks or months outside the human body. And these harmful bacteria do not as a rule multiply at all except in the human body. This makes it much easier to avoid them and keep free of them, because all we have to do is to see that none of the bacteria from sick people get near us. Think how hard it would be to avoid typhoid fever, for instance, if the germs were found naturally in the ground. It is hard enough to avoid the germs when we know that they are found only where they have been thrown.

How Bacteria Are Scattered.—The germs do seem to have great success in getting themselves scattered. Take, for example, the germs of diphtheria. They can be carried from one individual to another on such a little thing as a lead pencil, especially if the users of the pencil place its point in their mouths. Waving a soiled pocket handkerchief in the air may set the germs to floating in the air we breathe. The fingers which have touched such a handkerchief may grasp a doorknob and leave many germs behind. The next fingers that grasp the doorknob will take away some of the germs. The wash-woman, handling the linen, is especially likely to get the germs into her system. In a general way, **every solid or liquid particle that leaves the body of anyone suffering from a germ disease may carry the germs of that disease.** Whether it be saliva, tears, perspiration, bath water, or any other thing of this kind, it is dangerous, because it may have germs in it.

Careless People.—Since we know now the exact germ that causes each one of the diseases mentioned, and since we know

just how the germs are carried from one man to another, it is only a question of time till we will get the diseases under control. This knowledge is so new that the majority of people either do not know these things, or cannot realize them. You will see men and women with sweet character who go about spreading disease germs and causing sickness and death. Have you not seen consumptives spit on the floor? It would be kinder if the consumptive would set a steel trap to catch little children by the foot instead of setting this disease trap for them. Boys and girls in school now learn a great deal more about disease germs than their parents did when they were in school. The spitting nuisance is dying out. People must expectorate, but they can expectorate into a cuspidor or spittoon, or else carry several handkerchiefs, paper napkins or rags.

Important Points.

1. Bacteria are too small to be seen with the naked eye, and some of them are so small we have never even seen them with the best microscopes.

2. Bacteria live almost everywhere; especially in decaying food and dirty places.

3. Many bacteria live in our bodies, and a few are harmful to us. Most of the harmful ones make toxins which make us sick.

4. Many people have never learned the importance of not spitting on the floor.

Questions.

1. How small are bacteria? 2. Can they all move about? 3. How do bacteria multiply? 4. Name some places where bacteria live. 5. are all bacteria harmful to man? 6. How do they injure us? 7. Name some of the ways that disease germs are carried from one person to another.

CHAPTER III.

Diseases That Are Catching.

Did you ever have measles or mumps? If so, you could possibly tell just whom you caught the disease from. In other words, you could trace the source of contagion or infection. Some diseases, like measles and smallpox, are understood to be contagious, or catching. A better word to use is "communicable." A communicable disease is one that can be communicated or given to another.

Communicable Diseases.—There are a great many diseases that are communicable. Some diseases we now know to be communicable, but formerly we did not. For instance, typhoid fever is a communicable disease. We have always known that leprosy, cholera, smallpox, plague, measles, scarlet fever, hydrophobia, diphtheria and others were communicable; but we have learned only in our own generation that consumption, typhoid fever, malarial chills and fever, yellow fever, meningitis, granulated lids, infantile paralysis, erysipelas, and dengue, are also communicable. A great many well informed and educated people today do not realize that these diseases are communicable.

Scientists Who Gave Up Their Lives.—There have been many scientists who gave up their lives in an effort to find exactly how the dangerous communicable diseases are spread. In 1900, Dr. Lazear and Dr. Carroll, both United States Army surgeons, willingly contracted yellow fever in order to find the exact method by which it is spread; Dr. Lazear died after a few days; Dr. Carroll lived for several years, but finally died as a result of the yellow fever. Dr. Ricketts, a young physician of

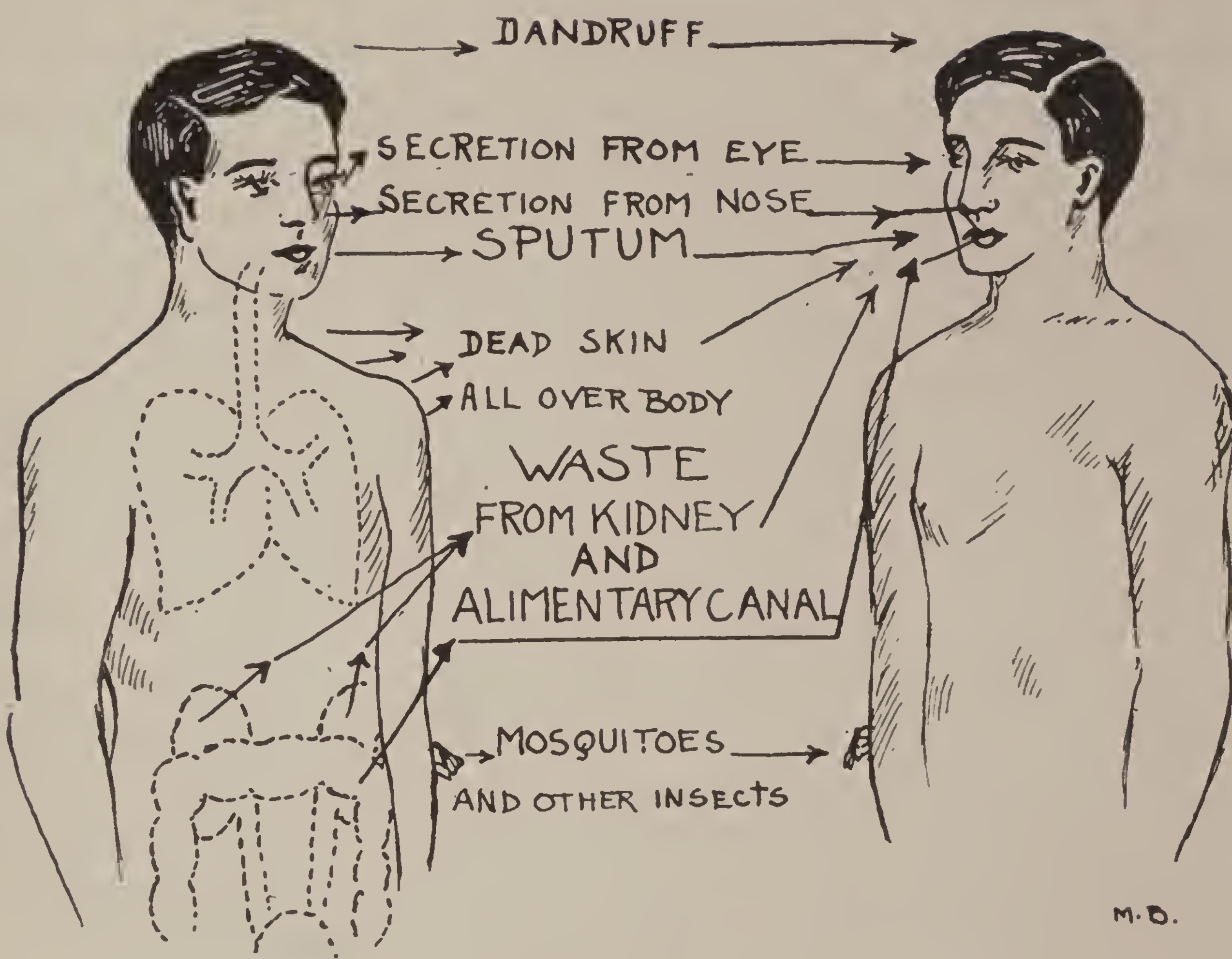

Fig. 9. This picture shows almost all the different ways by which germs or "contagion" can leave or enter the body. There is not one solid or liquid particle cast off from the human body which may not, under certain conditions, carry or convey disease. Beginning at the top, you will note that dandruff is cast off from the scalp. "Dandruff" is in all probability a contagious disease spread largely by combs and brushes in barber shops. Pus from the eye conveys sore eyes of several kinds, some of which can cause blindness. Secretion from the nose and mouth is the medium for spreading consumption, diphtheria, meningitis, paralysis of children, and other diseases. Dead skin from the surface of the body is believed to spread smallpox, scarlet fever, measles, and other diseases. Waste matter from the kidneys and bowels undoubtedly conveys typhoid fever, dysentery, Asiatic cholera, hookworm disease, and others. The mosquito is the only insect pictured, but many other insects carry disease from one person to another. You will learn more about these in Chapter XIV. From this page, learn one lesson: all contagion is due to solid or liquid particles which leave the body of the sick, while absolutely all such particles are capable of carrying some disease.

Chicago, went to Mexico in 1909 to study jail fever. During his experiences he became sick with the disease and died.

Diseases Are Conveyed by Solid or Liquid Particles That Leave the Body of the Sick.—By exposing themselves to danger, these scientists have found out just how most of these communicable diseases are spread. And yet some people still speak as though we did not know how they are spread. It is very important for us to realize that these diseases are not all spread in the same way; but we do know how most of them are spread. They are always conveyed by solid or fluid particles which leave our bodies. The air cannot spread disease except for the dust or little pieces of dried material that came from our bodies and float in the air. Water cannot spread disease except when the particles of solid or liquid material that leave our bodies are in the water. Even the mosquito cannot carry disease except when she has sucked up some of the blood of an individual that is sick. The fly is powerless to carry disease except when he has been walking over some of the waste that is cast off from our bodies.

How Disease Germs Leave the Body.—Try to rid your mind of that old, hazy, indefinite idea that "contagion" may be "atmospheric," or due to filth, or to bad weather, or to an unhealthy climate. Instead, think of contagion as something definite, that you can see and weigh and feel. Let us take note of the different ways in which particles leave the body. We have first the waste materials, which are thrown off by the kidneys, the alimentary canal, and the skin. Then we have the dried skin, which peels off every part of the body; these little particles are believed to carry the germ of smallpox. Then we have the hair and nails, and the hair may spread a very troublesome disease called ring-worm of the scalp. Then there is the sputum and saliva from the mouth,

and the nasal secretion, both of which are concerned in the spread of many different diseases, such as measles, scarlet fever, diphtheria, consumption, meningitis, leprosy, smallpox, and other diseases. The secretion from the eye is responsible for the spread of trachoma or granulated lids, and conjunctivitis, or sore eyes. All these things leave the body naturally. In addition, certain insects take away from our bodies blood, which conveys malaria. There are then many different ways by which solid and liquid particles leave our bodies, and there is some disease germ which may be carried by almost every one of these particles. To help us get a clear idea how communicable diseases are spread, let us take certain examples.

The Typhoid Germ Is Thrown Off From the Body in Body Wastes.—Typhoid fever is spread especially by the body wastes, which are thrown out from the sick room on the ground. Flies light on it, dip their feet in it, and fly into the dining room and walk over our food. Or else, the rain washes these body wastes into the well, spring, or river, and we drink the water containing the typhoid germs.

Tuberculosis Is Spread Especially by Dust From Dried Sputum.—For instance, a consumptive spits on the floor; the spit dries; and when the floor is swept, the dried spit is thrown up in the air in the form of dust, where it is inhaled by all those in the room.

Malaria Spread by the Mosquito.—In malaria, yellow fever, and dengue, the disease is not spread by body waste; but the mosquito gets a drop of blood from a patient suffering from malaria, and then bites a well man; and the malaria or other germs are injected into the well man.

Diphtheria Is Sometimes Spread by the Pocket Handkerchief.—The patient soils the handkerchief with secretion from

his nose. In handling the handkerchief, his fingers get the secretion and germs on them. He then handles knife and fork, and door knobs, or shakes hands with others. The germs are thus passed on to the hands of others, who, in turn, pick at their noses or eat with their fingers, or possibly use a pocket handkerchief, and thus place the germs in the nose, where they can reach the throat and set up diphtheria.

Granulated Lids or Sore Eyes Are Spread by the Secretion From the Eyes of One Suffering From the Disease.—The secretion or pus is collected on a handkerchief. At the same time some of it reaches the fingers. From the fingers it contaminates lead pencils, towels, door knobs, etc.

Every case of communicable disease is caused by some secretion or excretion from the body of some one sick with the disease.

Important Points.

1. All disease germs are carried from the body by some solid or liquid particles thrown off from the body.

2. Sputum and body wastes are especially likely to contain disease germs.

3. No disease can spread if we prevent the solid and liquid particles from leaving the patient and getting into or on some other person.

Questions.

1. Name all the solid and liquid particles which leave the body. (For example, body wastes, perspiration, etc.)
2. Name ten communicable diseases.
3. Name three diseases spread by sputum.
4. What is meant by communicable disease?
5. Describe how disease germs from body wastes can get from the ground into a new patient.

CHAPTER IV.

Our Protection Against Disease Germs.

From the chapters that have gone before, you have learned something of the enemies which attack our bodies from without, and it now remains for us to learn how wonderfully we are protected against these germ enemies. Let us not think for one instant that the germs have an easy fight even after they get into our bodies. Before any germ can make us sick, it must fight the battle of its life, and the human body wins out in the vast majority of cases. Did you know that the human body has a wonderful system of defense against disease germs?

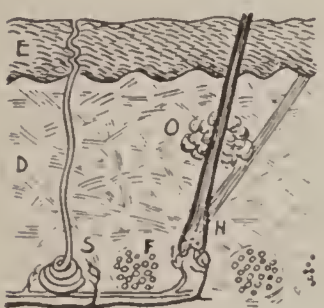

Fig. 11. The skin showing its protective horny layer.

The Skin as a Protective Covering.—To begin with, our skin is thick and horny on the outside and very few bacteria can penetrate it if it is kept healthy and whole. The best way to keep the skin healthy is to keep it clean with soap and water in reasonable amount.

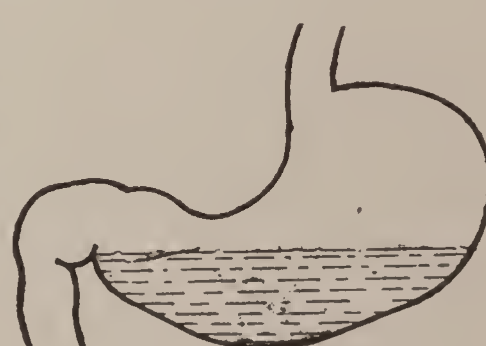

Fig. 12. The gastric juice in the stomach is fatal to most germs.

The Gastric Juice Kills Germs.—The stomach is well protected, too. It is the first stopping place of everything we swallow. The stomach is bathed at all times in a good antiseptic fluid, the gastric juice. The gastric juice is fatal to germs. It contains hydrochloric acid, and the acid itself will kill most germs. The pepsin will also digest germs, and so if our digestion is good not many germs will pass through the stomach.

Another Protection Against Germs.—But the body has another way of protecting itself against germs after they once get a foothold, and this is the most wonderful and beautiful safeguard that it is possible to imagine. This protection is shown in the case of measles. Did you ever notice that we have measles only once? And when we have it, it gets worse for about four or five days and then commences to get better. Now, why is this?

It is because the one attack has taught our body how to protect itself against the germ of measles. Just how the body does this we do not entirely know; but it is certainly plain that the body has hit upon some plan to protect itself against measles. This is very wonderful, and yet it is of so common occurrence that we pass it by without thinking much about it.

The Blood of a Typhoid Patient Will Kill the Typhoid Germ.—Now, typhoid fever is another disease that usually can affect the body only once. After one attack of typhoid fever, as in measles, the body learns to protect itself. It has also been noticed that the blood of a patient just recovering from typhoid fever has the power of killing the typhoid germ. This experiment is often tried in order to see if the patient has really had typhoid fever. A few known typhoid germs from some other source are taken on a glass slide and placed under a microscope; these germs can be seen moving about at a great rate, changing from place to place each second. Then if a very small drop of the blood of a typhoid patient is mixed with the germs, they stop moving, collect together in clumps, and may die. Blood from one who has never had typhoid fever will not harm the typhoid germs. This shows that during the course of typhoid fever, the human body has formed protective substances which have the power to kill the germs of the disease; and these protective substances are found in the blood.

Immunity.—In this experiment, the typhoid germs are killed and are clumped together so they cannot move. In other germ diseases other protective substances are formed in the blood which may cause the germs to dissolve in the blood. This is, of course, fatal to the germs. Whenever the human body has in any way acquired the power to resist a disease, so that the disease cannot affect it, we say that the body is immune to the disease. One who has had measles, is immune to measles; after one has had an attack of typhoid, he is immune to typhoid.

We Can Produce an Immunity.—We know why the body becomes immune in certain cases, because we can prove that there are protective substances in the blood. If we could only cause these protective substances to be formed in the blood, we could make the body immune and prevent the disease. You can see how desirable it would be to make people immune to any dangerous epidemic disease, that is, to immunize them. We do have at the present time some method of producing immunity in several diseases. When we produce an immunity in order to prevent disease we call it an "artificial immunity." The first disease for which an artificial immunity was produced, without the occurrence of the disease, was smallpox.

Jenner Produced the First Artificial Immunity.—A young English physician, by the name of Jenner, stumbled by accident on this method of producing an artificial immunity toward smallpox in the latter part of the nineteenth century. He did not know at that time that disease germs existed. He did not know any protective substances were produced by the body. But he did notice that every man who caught cowpox was afterward immune to smallpox. He observed this for some time, and it finally occurred to him to give cowpox to people in order to make them immune to smallpox. He tried it, and found that any one who caught cowpox could not be harmed

by smallpox. Since cowpox is a harmless disease, this method of producing an immunity against the dreaded smallpox soon became very popular, and has been so until this day. Now, the young physician did not know how the immunity was produced, but we now know that what he did was to place weakened smallpox germs into the patient. Cowpox is due to the same germ as smallpox, but when it affects the cow it becomes so weakened that it is almost harmless toward humans. These weakened smallpox germs then were put into the skin of the patient's arm, and his blood soon became filled with protective substances against the smallpox germs. After this, the individual was immune to smallpox. You see, the germs were too weak to do any harm to the body, but were capable of causing the body to form the protective substances.

All Artificial Immmunity Is the Result of Injecting Weakened or Dead Germs or Their Toxins Into the Body.—Owing to the work of Louis Pasteur, a Frenchman, who did his work about fifty years ago, we now know that disease germs can be weakened in various ways so that they can be put into the body without injuring the body, and yet produce an immunity. One way to weaken the germs is to chill them. Another way is to heat them. In fact, if the germs be killed completely, so that they cannot multiply at all in the body, they may in some cases cause the body to become immune. So we have learned two important things: first, when the body is affected by any disease, the body may produce protective substances which are found in the blood, and which may protect the body completely against the disease germs of that particular disease. And, second, it is possible in some cases to place weakened or dead germs in the body, so that the body

makes the protective substances and becomes immune without having had the disease.

Scientists Are Trying to Produce Artificial Immunity Against Other Diseases.—At this time hundreds of men are busy trying to find a way to make us immune to the dangerous diseases, especially tuberculosis, or consumption. No way is known yet to immunize one against this disease. We do have, however, methods of immunizing against the following diseases: smallpox, rabies or hydrophobia, typhoid fever and Asiatic cholera.

Vaccines.—These immunizing remedies, consisting of dead or weakened disease germs, are called **vaccines.** Formerly smallpox vaccine was the only vaccine known, but we now have typhoid vaccine, cholera vaccine and others.

The Immense Value of Typhoid Vaccination.—A striking example of the value of vaccination against typhoid fever was seen in the maneuvers of the United States army at San Antonio in the summer of 1911. Many thousands of soldiers were camped in San Antonio for several months during the typhoid season. Most of the soldiers had been immunized against typhoid fever by the injection of dead typhoid bacilli. Not one single soldier that had had the full dose of the dead bacilli developed typhoid fever. In the Spanish-American War there were twenty thousand cases of typhoid fever and two thousand deaths. This was before the army surgeons had commenced the use of the dead typhoid germs. As a rule, when a large army takes the field more men are killed by typhoid fever than by bullets. You can understand how the germs of typhoid are always present in all large crowds of men, because there are so many typhoid carriers in the world. In this country it would probably be almost impossible to get together two thousand men without having a few typhoid

carriers among the number. You will learn in a later chapter that a typhoid carrier is one who has typhoid germs in his body, but who is not sick. When you take into account the fact that all large armies have always suffered from typhoid fever, you will see that the **good health of the soldiers at San Antonio was something new in the history of the world.**

At the time meningitis was prevalent in Texas, in 1911 and 1912, some physicians used injections of the dead meningitis germs in order to immunize certain persons against the disease. It is to be hoped that as time goes on, other vaccines will be perfected, so that epidemics will be a rare occurrence.

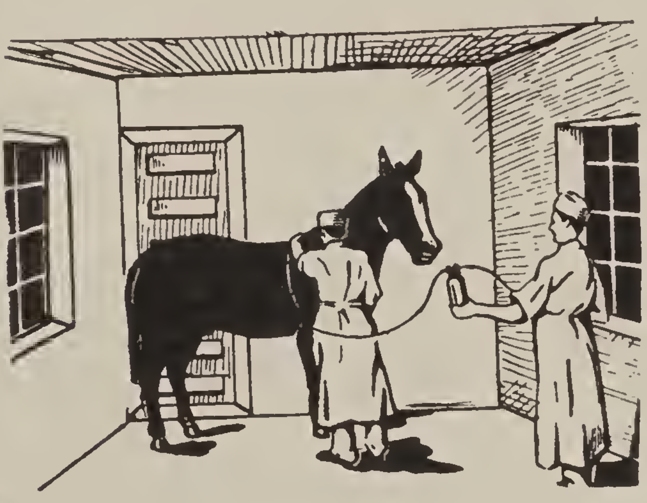

Fig. 13. Injecting the horse with diphtheria toxin in order to form diphtheria antitoxin in his blood.

Antitoxins and Serums.—Up to this time we have noticed how we may produce an artificial immunity by injecting dead or weakened bacilli into the body. There is another way we may produce a partial artificial immunity, which does not last very long, and this we will now take up. We can first immunize an animal by injecting the weakened or dead bacilli, and then **use the serum of the animal to immunize human beings.** Blood serum is the clear yellowish liquid that forms when blood clots or coagulates. The best example of this is the serum we use to prevent or cure diphtheria. In order to obtain this serum, we first immunize the horse against the poison or toxin formed by the diphtheria bacillus. We do this by injecting the horse with

gradually increasing amounts of the diphtheria toxin. When we have done this, no matter how much toxin we inject, the horse is uninjured, for his blood contains protective substances which prevent the diphtheria toxin from harming him. If now we bleed the horse and take his serum it contains the protective substances, and this serum, injected into a child with diphtheria, will cure the child. What we have done is to immunize the horse, and then borrowed the immunizing substances from the horse. Of course, the serum from the horse must be handled in a very cleanly manner. The picture shows a horse being injected with the diphtheria toxin. The serum used to immunize human beings, in this case, horse serum, is called "anti-toxin." "Toxin" means "poison," and "antitoxin" means "against the poison," because the serum counteracts the poison of the germ.

Tetanus or Lockjaw, Meningitis and Diphtheria, Are Treated by Serum or Anti-Toxin.—An attempt has been made to produce serums for the cure of many of the communicable diseases, including even tuberculosis; but up to this time diphtheria, meningitis and tetanus or lockjaw, are the only diseases that have been cured by serum. You will, of course, notice the difference between immunizing and curing. To immunize a person you inject the serum or vaccine and prevent the disease from developing; but to cure the patient, you inject the serum after the patient is sick of the disease. We believe that the serums used for the cure of diphtheria, tetanus and meningitis are all valuable for immunizing persons, but the immunity does not last so long as when we produce an immunity by injecting the dead or weakened bacilli. It is very important to notice that the tetanus serum is of very little value after the patient has developed tetanus. If we inject the serum, however, immediately after the nail thrust

has been received, the serum will almost always prevent the development of tetanus or lockjaw. For this reason it is important that all wounds made by explosions or nails should be treated properly at once. You will learn more of this in chapter XLV.

Smallpox Vaccination Is of Greater Importance Than Any Other Immunizing Remedy.—Of the vaccines and serums mentioned, smallpox vaccine is by far the most important, because **smallpox is the most contagious of all diseases.** Before the discovery of vaccination, smallpox attacked the majority of all citizens. You might well ask, why is smallpox so contagious? Smallpox is very contagious, and in epidemic form is very hard to control, for the following reasons: first, almost everybody is susceptible to smallpox, and takes it the first time exposed to it; second, the smallpox germ is given off from the body in enormous numbers, both in the sputum and nasal discharges, and in the particles of dead skin which you have read about in the chapter on "Diseases That Are Catching;" third, the smallpox germ is very long-lived, and will live in clothing for months; fourth, the skin does not show any eruption for several days after a smallpox patient is taken sick, but during this time the patient is giving off the germs by millions, and consequently is spreading the disease to dozens of people before he knows he has it. All these things make it almost **impossible to control smallpox except by vaccination.**

Smallpox Is a Very Fatal Disease.—It is absolutely necessary to control smallpox in any way possible for it is a very fatal disease. In some epidemics as many as forty to sixty per cent of all cases die. Among those that do not lose their lives, many are disfigured for life by the pits or scars. Others are weakened in various ways so that they are never

able to bear the burdens of life as they should. And so we see many reasons why we must limit the occurrence of smallpox.

Fig. 14.—Two children in the municipal hospital of Philadelphia, one unvaccinated and the other vaccinated on the day of admission. The crust is still seen upon the leg. This child remained in the hospital with its mother for three weeks, and was discharged perfectly well. The unvaccinated child who was admitted with smallpox died.

Vaccination Is Practically a Sure Preventive of Smallpox, and there is no single fact in science which has been proven more thoroughly than this. For the first few years after vac-

cination the protection is practically complete, and after that it is gradually lost. The value of the protection afforded by vaccination is shown by a Texas epidemic which occurred since 1910. In this epidemic, there were ninety-eight who had the disease. Out of this number only two had ever been vaccinated at all; one of these was an old man, who was vaccinated sixty years ago when he was a child; the other had been vaccinated over fifteen years. Neither of these men had the disease in its worst form, and both recovered. Many of the unvaccinated died. In May, 1904, the United States Army Ship Liscum left Manila with 292 persons on board. During the first week at sea an unvaccinated child became ill with smallpox. Everyone on board except three persons had been vaccinated. Inside of fourteen days all three of these persons developed smallpox, while not a single person of the 289 vaccinated ones took the disease. The medical officers of the United States Government strongly recommend vaccination, because they know it is the only practical way to keep down smallpox.

It Is Our Duty to Be Vaccinated.—In thinking over the question of vaccination we should remember that we not only owe it to ourselves to be vaccinated, in order to protect ourselves, but we also owe it to our fellow citizens to be vaccinated in order to protect them. Nowhere else can we affect our neighbors more than by our health; if we take a contagious disease we are very likely to cause someone else to take it.

When and How Often to Vaccinate.—Every child should be vaccinated before starting to school. If this vaccination does not take, it gives no protection and should be repeated until it does take. After one good scar has been formed there will be complete immunity for several years and partial immunity

all through life. It is well to vaccinate again about ten years after the first vaccination, and if this takes, the immunity is generally complete for life.

Vaccination Will Protect Even If Done After Exposure to Smallpox.—The picture shows two babies who were kept in the same hospital. The story of these children is given under the picture. One important lesson to learn from this picture is this: vaccination will prevent smallpox, even after exposure has taken place. In other words, if you are exposed to smallpox today and are vaccinated immediately, the vaccination will develop in time to prevent the smallpox. This is due to the fact that vaccination develops more rapidly than smallpox. We believe that smallpox enters the body through the nose, and it takes it several days to develop. When we vaccinate, we give the vaccine a certain advantage, and it develops more rapidly, thus "heading off" the smallpox.

The White Cells of the Blood Destroy Bacteria and Germs.—In studying vaccination against smallpox, however, let us not forget that this is only one kind of artificial immunity. We have studied also the artificial immunity due to serum from an immunized animal, for instance, the horse serum, which contains diphtheria antitoxin. Then we have studied the protection which our skin affords us, and the protection afforded by the gastric juice which kills germs in the stomach.

Fig. 15.—White cell of the blood swallowing and digesting germs.

There is one other protection that is very important and that is due to the white blood cells. These little cells act like little soldiers or policemen, and swallow up all the bacteria

they can get in reach of. They collect in all sore places or inflamed places. They swallow the bacterium if they can, but if the bacterium is too poisonous they get close to him anyway and die there. There is no more heroic example in the world than that of these little cells trying to protect us. They try either to swallow the germ, or to block the way so the germ cannot spread through our body. If it is necessary they will block the way with their dead bodies. This is one example of unselfishness that cannot be surpassed in the world. The little white cells rush to any place of danger, and take up their stand to prevent the bacteria from spreading. They get so close to the danger that they die, but they seem never to retreat. The dead bodies of these little white cells make up the fluid which we call corruption or pus, such as that which comes out of a boil or rising when it is opened. We have been protected, but the little white cells have lost their lives for us.

From what we have learned, you see that we have many ways of protecting ourselves against bacteria. When they try to live in our bodies, they usually fail and lose their lives. As soon as the bacteria start to multiplying anywhere in our bodies, our bodies start to making the antitoxins, and as a rule the bacteria are killed in a short time.

Our Body Is Well Protected Against Bacteria.—There are probably other ways by which the body protects itself which we know nothing about. For years we did not know about these, and it is almost sure that as we learn more about ourselves, we shall learn still more wonderful things.

No Need for Alarm.—If you take good care of yourself and try to live well you need not feel apprehensive or frightened about disease germs. Live by the rules in this book until you find better rules to live by, but remember that your body is a

marvelous creation, a wonderful thing, and that it has not been made and put here without protection.

Important Points.

1. The human body has a very complicated and very wonderful set of defenses against disease germs.

2. The power of the body to resist disease germs is called immunity.

3. Nearly all the dangerous germ diseases except diphtheria and pneumonia are followed by an immunity; that is, after one attack, we are immune against the particular disease.

4. The first physician to immunize a patient artificially was Jenner, over a hundred years ago, and he produced an immunity against smallpox by giving a patient cowpox, a harmless disease.

5. Today we have two ways of producing an artificial immunity; first, by injecting weakened or dead bacilli, as in the case of smallpox or typhoid fever; and, secondly, by injecting the serum of an animal that has been immunized, as in diphtheria, tetanus and meningitis.

6. The white cells of our blood attack some disease germs, and either swallow them or are killed by them.

7. Smallpox is so contagious that we cannot control it without vaccination.

8. Vaccination is a safe and easy method of controlling smallpox.

Questions.

1. How does the skin protect us against disease germs? 2. How does the stomach or gastric juice kill bacteria? 3. Name one disease that usually attacks a person only once. 4. What is the effect of mixing the blood of a typhoid fever patient with typhoid

bacteria? 5. Will the blood of any healthy individual have the same effect? 6. Name one way by which bacteria can be killed by the body aside from the stomach and gastric juice. 7. What word do we use to describe one who has had measles and cannot have it again? 8. What is artificial immunity? 9. What physician first produced an artificial immunity to prevent a disease, and what was the disease? 10. How did he produce the artificial immunity? 11. What do we have to introduce into the body in order to produce an artificial immunity? 12. Give several ways to weaken disease germs. 13. Mention one important fever that can be prevented by artificial immunity. 14. Compare the number of cases of typhoid fever which occurred among the U. S. soldiers during the Spanish-American War with the number of cases occurring during the San Antonio encampment. 15. Account for this difference. 16. Which of the following diseases are prevented by vaccines, and which by antitoxins: Typhoid fever, meningitis, diphtheria, smallpox, cholera, tetanus? 17. Why is it important to treat promptly a nail thrust or a wound made by powder? 18. What is a toxin? 19. What animal do we inject the toxin into in order to form antitoxin? 20. Does the immunity caused by the injection of antitoxin into the human body last as long as the immunity produced by the injection of dead bacteria? 21. Why is smallpox so contagious or so hard to control? 22. Give some proof that vaccination will prevent smallpox. 23. Give the main facts about the two babies shown in the picture. 24. Tell how the white cells protect us against disease.

CHAPTER V.

Typhoid Fever.

Typhoid fever is a good deal more like measles than most of us realize. It causes a "breaking out," or rose rash, like the rash seen in measles, although there are generally only about a dozen or two spots in the skin at one time. It is like measles, in that each typhoid patient catches the disease from a previous typhoid patient, as we shall see later. It is like measles, in that it seems to affect the young people especially, for old people are less often affected. It is important to remember, that each typhoid patient must be carefully handled to avoid giving the fever to some one else.

Fig. 16. — Typhoid bacteria showing the little lashes by which they move.

Importance of Typhoid Fever.—Typhoid fever is a disease that is very common in nearly all parts of Texas. It is common in town and city. Every year there are about nine hundred deaths from typhoid fever reported in our State; and yet it is a disease that can be prevented more easily than most other diseases. In other words, we can do more good in preventing sickness and death by studying typhoid fever and its prevention, than in any other way. Typhoid fever is a contagious disease; see Rule 3, Sanitary Code, page 337.

Germ of Typhoid Fever.—Now, typhoid fever is due to a germ. The germ is a little rod-shaped germ that lives in certain parts of the intestine. It also lives in the blood and travels all over every part of the body. It injures the entire body, but is especially harmful to the intestine, for it causes ulcers or raw spots in the intestine. Sometimes these raw

ulcers are so deep that they cause a hole in the intestinal wall, and the patient frequently dies. The hole through the intestinal wall is called a perforation. If the ulcer does not eat out a hole entirely through the wall of the intestine, it may still cause the patient's death by bleeding. Such a bleeding is called a hemorrhage; in this case it is a hemorrhage of the intestine.

Typhoid Germs Multiply Only in Human Body.—Now, you have learned where the germ lives and multiplies. And this is, except in milk, the only place in nature where the germ multiplies. The typhoid germ does not even live in the lower animals, and they do not have typhoid fever. But the typhoid germ can live for a few days in water or milk, or it can live for a longer time in filth. It can live long enough to be carried to a new patient and cause the disease in him.

Typhoid Germs in Waste Matter.—No doubt you are wondering how the germ can get into the mouth of the new patient, to be swallowed by him. There are several ways by which the germ can pass from the sick man to a well man. For instance, the germs are swarming by millions in the unclean waste matter that is thrown off by the intestine. When we eat any food, the digestible portion of it is dissolved and absorbed in the stomach and intestine; but there always remains a certain amount that is not digestible, and hence is useless to the body. This passes entirely through the intestine and is cast off from the body as body waste. This body waste from a typhoid patient is simply alive with typhoid germs. If you could see them, you would see that they are more numerous than blackbirds in the biggest flock of blackbirds you ever saw.

Flies Carry Typhoid Germs on Their Feet.—One single fly can carry enough of this unclean and dangerous material on

one foot to cause a boy or girl, or even a grown man, to take typhoid fever. The fly acts as a messenger between the typhoid patient and the well man, and causes the well man to become sick. The fly goes out in the back yard, where all the unclean body waste from the sick room of careless people is poured on the ground. He lights on it, and puts his feet in it. The fly's feet are covered with hair, making it easy for unclean material to stick to his feet. The fly may then pass into the dining room or kitchen and walk over the butter, or the jelly. Can you imagine how the fly leaves a trail of germs behind? The picture shows a flat dish of jelly that a fly has crawled over. The germs have multiplied for twenty-four hours and caused the spots which you see. Anyone eating this jelly now would swallow more germs than there are people inhabiting the United States. If some little boy had eaten the jelly just after the fly squirmed across it, he would have been unable to see any trail, but would nevertheless even then have swallowed more germs than the number of inhabitants in your county.

Fig. 17.—Foot of fly, showing how it can carry germs.

Fig. 18.—Tracks made when a fly walked across a plate of gelatine. Each dot is a colony of germs.

Do you see how easy it is for the germs to pass from a sick to a well man?

Typhoid Germs in Drinking Water.—But this is only one way. The germs can also reach us by another route, and that is in the drinking water. Suppose there is a family living on a hill side, with the back yard higher than the front. The well will probably be near the house. A great many unclean things are thrown on the ground near the well, and as the

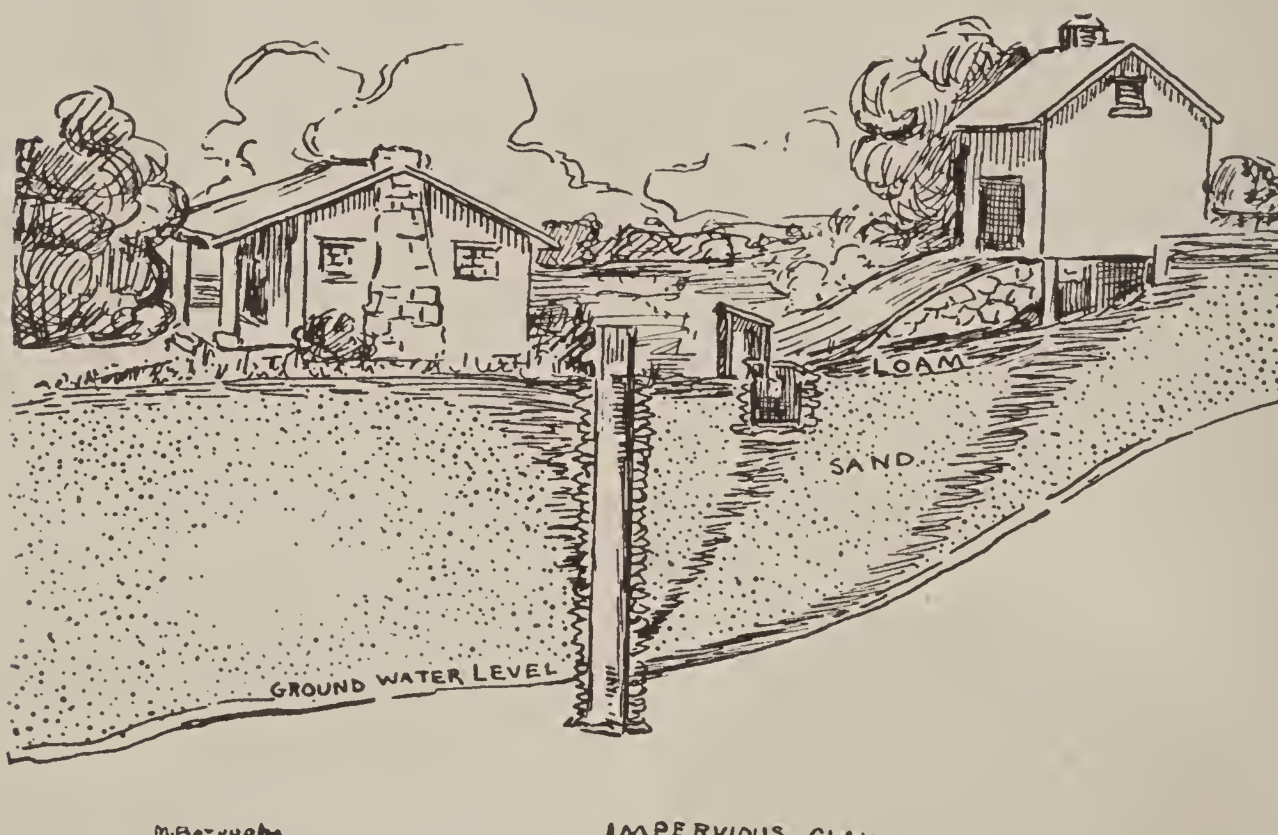

Fig. 19.—Showing a well located in the wrong place. The drainage all seeps into the well.

back yard slopes up the hill, any rain that falls will tend to wash these unclean things back toward the well. If the well is not cased in at the top with a water tight casing, some of the water and filth may drain into the well. A great many wells are cased in at the top with rocks or pieces of stone. Water can easily trickle through the cracks between the pieces of stone. In a loose soil, the germs can soak through the soil without being filtered out entirely. The water may contain millions of typhoid germs that came from the body waste of

the typhoid patient. If any one drinks the water of this well, he is likely to become ill with typhoid fever in about twelve or fourteen days; for it takes about twelve or fourteen days for typhoid fever to develop after the first germs enter the body. Hence in trying to trace the source of a case of typhoid, we always inquire particularly where the patient was about two weeks before taking sick.

Typhoid Germs in Milk.—Most typhoid is spread in one of the two ways described, but there is one other favorite road which the typhoid germ likes to travel, and by this we mean the milk route, or the dairy route. Dozens of epidemics have occurred in which practically all the sick people had been using milk from the same milk dealer. Typhoid germs multiply in milk very rapidly, and a single fly can poison a large can of milk. If this be mixed with other milk it will poison that, and so there is no limit to the amount of harm that may come from germs in milk.

How the Germs Get Into Milk.—There are several ways the germs can get in the milk. It may be from flies. It may be from well water used to wash the milk vessels, or it may be from the fingers of one of the milk maids or milk men. One of the men or women handling the milk may be a typhoid carrier.

Typhoid Carriers.—And what is a typhoid carrier? A typhoid carrier is a man who has the typhoid germs in his system, but who is not sick. Usually a typhoid carrier has had typhoid fever at some previous time, and recovered his health, and yet the germs have never left his body. This seems hard to believe, but is absolutely true. It is easy to see how a man could have a few germs in his body after he commenced to get well, but the typhoid carrier actually has many germs in his body for months or years after he has gotten well from his siege of fever. See Fig. 55.

When you studied the chapter on immunity you learned how it is possible for a deadly disease germ to be harmless to individuals that are immune. In the case of a typhoid carrier, he is immune to the typhoid germ, and cannot be injured by it, and yet the germ has the power to live in his body. Probably the germ cannot live in his blood, and it certainly can do him no harm.

Typhoid Carriers Give Typhoid Fever to Those Around Them.—Just think what terrible damage a typhoid carrier can do! Without knowing it, he can give this disease to many of the people he holds most dear, and to many strangers that have done him no harm. The United States Army will not allow a known typhoid carrier to enlist in the army. He would be too dangerous to his comrades. But not many typhoid patients develop into typhoid carriers, and this is fortunate.

Fig. 20.--Washing the hands. (This should be done especially before eating.)

Necessity for Washing the Hands Frequently.—A great many people get the typhoid fever germs by shaking hands with a typhoid patient, or by handling his bed or clothing. Anything a typhoid patient has touched is likely to be soiled with the germs. The way to avoid getting the disease in this way is to rinse the hands carefully in soap and water, or better in an antiseptic solution, after having touched a typhoid fever patient.

Anyone who waits on or nurses a typhoid patient should avoid doing the cooking and bread making for the family. If it is necessary for her to do so, her hands should be disin-

fected thoroughly before she enters the kitchen. Now you have learned the most important routes for the spread of typhoid fever. There are many other ways that it can be spread, as, for instance, by oysters, lettuce, radishes and other articles of food commonly eaten raw.

Fig. 21.—Plate, knife and fork. The typhoid patient should keep his separate from the family.

How to Decide the Manner of Spread of Typhoid After an Epidemic Occurs.—There are certain ways we can form an idea as to how a given epidemic is spread. This is very important, too.

(1.) **The epidemic of typhoid fever spread by the fly** always occurs at a time when flies are plentiful, or, in other words, in warm weather. (2) An epidemic spread by the fly usually occurs in those parts of town where there are most flies. (3) An epidemic spread by flies is never sudden or "explosive" in its nature, but drags along through the summer, getting a little worse as August and September approach, and dying after frost falls. (4) In an epidemic spread by flies each case is usually near some other case.

(1.) **The epidemic spread by drinking water,** if in a town with public water supply, usually is explosive or sudden, and a dozen or possiby a hundred people will become sick the same week. (2) In an epidemic spread by drinking water, cases occur in widely separated parts of town. (3) An epidemic spread by drinking water usually follows certain cases of typhoid which have occurred upstream along the banks of the river supplying the town.

(3.) **The epidemic of typhoid spread by milk** is likely to affect persons who take milk from a certain dairyman; that is, persons affected are all on one milk route. In an epidemic spread by milk, children and old people are especially affected, because they use most milk. Such an epidemic is likely to affect well-to-do people in cities, because they use more milk than poor people; in small towns in Texas, almost all citizens are able to get milk, and this point is not noticeable.

Disinfectants Used to Kill Typhoid Germs.—Now comes the important question how to prevent typhoid fever. The most important thing is to kill all the germs as fast as they leave the body of the patient. This is best done by chemicals or drugs which are poisonous to germs. We call these chemicals "disinfectants." In chapter XVI, on disinfectants, you will learn more about how to use them. Most disinfectants are poisonous to human beings as well as to germs, hence their use should be left in the hands of grown people.

Fig. 22.—Hole dug to receive typhoid wastes. The lid is to keep flies out. Disinfectant should be poured into the hole.

All body waste, discharges, secretions, excretions, and all slops generally from the typhoid sick room should be disinfected thoroughly. This may be done cheaply with chloride of lime, with pure or crude carbolic acid, with corrosive sublimate, or by patented preparations made from coal tar. These are mentioned and described in Chapter XVI.

Good Method of Disinfection for Country Districts.—A good way to do in the country is to dig a hole two feet square and two or three feet deep in the back yard, at least one hun-

dred feet from the well. First, disinfect the slops, then pour them into the hole, and have a wooden or wire gauze lid to cover the hole to keep out the flies. Sometimes the method used had best be determined by the physician caring for the case.

Fig. 23.—The slop-bucket is the citadel of typhoid fever. (When we disinfect the body wastes, we "head the typhoid germs off.")

Dangers of Carelessness.—If you do not disinfect the body wastes from the patient, you are scattering sickness and death among your neighbors. It would be far better to turn loose a box of rattlesnakes in your back yard than to pour out the body wastes with the living typhoid germs.

How to Handle the Laundry of a Typhoid Patient.—It is not right to turn a lot of typhoid linen over to a wash woman or laundry without warning. In handling the soiled linen, the wash woman or one of the laundry workers may get the disease. All soiled linen from the sick room should be either soaked in a disinfectant solution before being handed over to the laundry, or should be wrapped in a clean sheet or pillow case, so that the wash woman can drop it into a pot of boiling water without touching the soiled linen.

Fig. 24.—Disinfecting the linen. The bundle is dropped into boiling water without being undone.

The plates, knives and forks and other utensils used by a typhoid patient should be kept separate from those of the family, and should either be soaked in

antiseptic solution or placed in a dish-pan of water and boiled. These points will naturally be looked after by the physician, and in case a trained nurse is in attendance, the physician will probably entrust all these things to her.

Length of Time the Danger of Contagion Lasts.—These precautions should be kept up until the physician declares the patient to be free from typhoid germs. At the present time, 1912, it is impossible for a bacteriological examination to be made in each case, but Texas will not be free of typhoid fever till we get into the habit of making these tests regularly in all cases.

How to Avoid Catching Typhoid From Neighbors.—But suppose that the case of typhoid fever is in a neighbor's family, how can we escape catching it? There are several practical things we can do. The most important is to use screens and sticky fly paper, and wage war on the flies in the neighborhood in every possible way. We must also notice the lay of the land, to see if any drainage occurs from our neighbor's premises into our own. If he is on the uphill side of us, we must be extremely careful, because a rain may wash his back yard, and the washings may trickle into our well. This may be good for his back yard, but it is certainly not good for our well. If there is a reasonable doubt as to this point, we must boil the drinking water. The patented household filters are as a rule worthless. Those who object to the flat taste of boiled water can restore the taste to it by pouring through the air a few times from one pitcher to another.

When Cistern Water Is Dangerous.—If a cistern be used on the premises, it is well to have a care about English sparrows and pigeons, which may carry typhoid germs on their feet and soil the roof. This point is rather important in towns.

When typhoid is occurring all around you, it is well to first

see that your dwelling is free from flies; then convince yourself as to the purity of the drinking water. Then inquire as to your milk supply, and your supply of raw vegetables and oysters. These subjects are discussed more fully in chapters XX. and XXI.

Those who are going to take care of typhoid patients will probably desire in some cases to be made immune to typhoid fever by antityphoid vaccinations.

The subject of antityphoid vaccination is treated in chapter IV.

Fig. 25.—A very faulty cistern. The birds carry germs from the ground to the roof on their feet; the cistern is open and is a breeding place for mosquitoes.

Asiatic cholera is a very fatal disease, due to a little comma-shaped germ, which, like the typhoid germ, is spread by unclean drinking water. It is not likely to enter Texas, but after the Panama Canal is opened up, it might get a start here. The way to prevent cholera is to quarantine those who are sick, and to use drinking water which is free from germs.

Important Points.

1. Typhoid fever is a definite disease, and one attack is usually followed by immunity.

2. There are over nine hundred deaths reported in Texas from this cause each year.

3. At this time there is no better way to improve the health of the people of Texas than by directing our efforts against typhoid fever.

4. The typhoid germ does not multiply anywhere outside the human body except in milk.

5. Typhoid germs always come from the solid and liquid material thrown off from the body.

6. The fly is the cause of more epidemics of typhoid fever in Texas than has been realized in the past.

7. Drinking water is usually polluted by drainage water which runs into the well from the top.

8. By carefully observing certain facts as described on page 39, it is possible to decide with some accuracy whether a given epidemic is due to the fly, the water, or the milk of a community.

9. Typhoid germs can live in the body of a healthy man, and other people can catch the disease from him.

10. No patient should handle the public milk or food supply of a city for at least twelve months after recovering from typhoid fever.

11. No person nursing a case of typhoid fever should handle the milk or food of a family.

12. The slop bucket is the stronghold of typhoid fever.

13. Typhoid vaccination is a harmless procedure and is valuable in preventing typhoid fever.

Questions.

1. Which causes more typhoid fever in Texas, the fly or the drinking water? 2. What is a typhoid carrier? 3. When does a

person become immune to typhoid fever? 4. Why is it dangerous for a person just getting up from typhoid fever to sell milk? 5. Why should the nurse not make the bread for the family in case of typhoid fever? 6. After coming from the typhoid sick room what should you do before eating? 7. What is the safest way to dispose of the slops out in the country or on a farm? 8. What part of the fly is especially likely to carry germs? 9. How do the typhoid germs get into milk? 10. Suppose a large mass of decaying vegetables and small animals is left near a house, if there were no human waste material in it, could it cause typhoid fever? 11. How many deaths are reported in Texas from typhoid fever each year? 12. Can we accomplish anything by trying to prevent typhoid fever? 13. What kinds of unclean material does the typhoid germ live in? 14. What part of a well is most likely to let the typhoid germs get in, the top, the sides or the bottom?

CHAPTER VI.

Consumption or Tuberculosis.

Consumption is such a common disease that some boys and girls think they know all about it already. But common as it is, there are a great many interesting things about consumption that will surprise you when you hear them. For instance, there are about six people that get entirely well of consumption for every one that dies of it.

Majority of People Have Consumption.—Almost everybody that lives to be fifty years old has had consumption at some time during his lifetime, and most people never know when they have it. At least three out of every four men have consumption before they die. You wonder how we know they have consumption if they do not know it themselves. We know it because thousands and thousands of bodies have been examined after death, and a large majority of them have shown at least some scars from an old consumption that had healed up. Many of these people, in fact, most of them, never dreamed they had ever had this disease. This shows us two very important things: it shows us how gradually the disease can begin, and it shows us how many people get well of consumption.

Of course, you know that the organs most often damaged by this disease are the lungs, and that the usual signs of the disease are a cough that lasts a long time, and loss of weight. Most people that cough constantly are consumptives.

Lungs Are Especially the Seat of Consumption.—The lungs are so important in the spread of consumption that we shall not study the other organs very much; but yet it is well to

know that the consumption germ can live in the skin, in the intestines, in the bones, in the kidneys, in the coverings of the brain and cord, and in fact anywhere in the body. By far the greater number of cases of consumption, however, are consumption of the lungs. We have almost given up the use of the word consumption except in speaking of the lungs. When we mention the disease in the other organs we give it the longer name, "tuberculosis." We then give the name of the organ affected, as, for instance, tuberculosis of the lungs or hip.

The Germ of Consumption.—The germ of tuberculosis is a little rod-shaped bacterium. It cannot move, but remains still until something blows it or washes it along to a new place. The tubercle bacterium cannot live but a few hours if placed on a pane of glass in the sun; it can live a few days on the surface of the ground in a sunny place; but it can live for weeks and possibly months when it is a dark, moist place. It does not multiply, however, after it leaves the human body. A house that has been occupied by a careless consumptive that spits on the floor is dangerous for months afterward.

Fig. 26.—The germ of consumption, called the Tubercle Bacillus.

There are other animals that can have tuberculosis besides man. Man does not catch the disease, however, from any other animals except cattle, that is, cows. Little children can get tuberculosis of the intestines or bones or glands from tubercle germs in cow's milk.

Method of Spread of Consumption.—It is very easy to account for the spread of consumption, but the wonderful thing is that so many escape the disease. Just think of the people that have consumption for ten years and go about spitting on

the floor, on the sidewalks, on the floor of street cars, and even on carpets. The spit dries up and people walk over it, and grind it into dust; the wind blows it up into the air, and men breathe it into their lungs. Worst of all, some people aren't even satisfied to leave this dust alone, but must take a broom and sweep it up dry. Of course, this is unwise. Dry sweeping and dry dusting in our homes is really dangerous.

Fig. 27.—The careless consumptive spits on the floor; the spit dries and is swept up into the air when the girl raises a dust; the baby plays on the floor.

Evils of Dry Sweeping.—If you were to try to write an essay or composition on how to spread consumption germs you could not possibly think of any way to spread them which would equal the dry sweeping method. If you took an atomizer and put the dust in it and attempted to blow it into people's noses, you would not spread the germs nearly so well as by the dry sweeping method. You can take a broom and go into a room and raise a dust in three minutes that will float in the air for at least an hour or two, and will place germs first in the nose of the sweeper, and then in the noses of all others who enter the room for a long time after the sweeping is finished. And after the dust settles, it is there to be stirred up again with the feather duster. When you think of this process that is going on in thousands of homes in Texas, it is enough to remind one of the sacrifices which the Aztec Indians in Mexico used to make. They killed people on a big round stone altar. They killed them as a sacrifice to

their cruel gods. When we spread consumption, we kill people as a sacrifice to our own ignorance or carelessness.

Aren't you glad there is a remedy for this? We can stop this cruel sacrifice. We have plenty of water to sprinkle the floor with, and we can stop spreading consumption in our homes at any rate. Besides, it is against the law in Texas for any porter or janitor to sweep a public building by the dry method, without sprinkling. See Sanitary Code for Texas, page 337, Rule 54.

How to Avoid Raising a Dust.—There are several ways of avoiding a dust when we sweep our homes. We should avoid heavy carpets on the floor, and should have a floor as smooth as possible. Rugs which can be taken out and shaken or beaten are not dangerous. If a carpet is in use, it should be swept with a carpet sweeper, or, better still, with a vacuum cleaner. The floor can be cleansed in several ways. If it is a hall, the floor may be oiled, and brushed up with a brush instead of a broom. In the case of a bedroom, with a common pine floor, such as we find in the vast majority of Texas homes, dampened sawdust may be scattered over the floor before sweeping. In some places sawdust is scarce, and pieces of newspaper can be dampened and scattered on the floor before sweeping. Of course, in all cases, a brush is better than a broom.

In dusting, a rag or cloth should be used, and it should be dampened with water or greased with raw linseed oil, so that the dust will stick to the cloth. It is not necessary to use any antiseptic in the water. See also Sanitary Code for Texas, page 337, Rule 54.

Danger of Feather Duster.—Feather dusters are too dangerous to have in a dwelling of human beings. It is all right to

use them out in the open air to brush the dust off a buggy or automobile. But the dust in the houses is dangerous. House dust is more dangerous than street dust, for two reasons: in the first place, the sunlight of the street will kill any germ in a few days; and, in the second place, almost all disease germs come from human beings, and around the house you find more human beings, and hence more disease germs.

Fig. 28.—The careful consumptive sleeps by himself.

Consumption Spread by Droplets.—When a consumptive coughs, he blows out a number of little fine drops of spit, and these little drops, or droplets are so small that some of them float in the air like fog on a misty day. For this reason, it is dangerous to have your face close to a consumptive when he is coughing or even talking. Have you not noticed little pieces of saliva or spit leap out of a man's mouth when he is talking? There are a great many little droplets which are invisible, but which contain germs, and are dangerous. For this reason it is dangerous to sleep in the same room with a consumptive. In fact, no consumptive ought to sleep in a room at all. He ought to sleep in the open air. Don't ever sleep in the room with a consumptive. There is always a way to avoid it, especially in our Southern climate, where bitter cold weather seldom comes.

Fig. 29.—If possible he sleeps in the open air or in a window tent.

Kissing.—A consumptive should never be kissed early in the morning until he has washed his face, and even then, not on the mouth. Kissing him on the cheek is not dangerous if he has washed his face. It is the dust and uncleanliness that are dangerous. At the same time, it is very wrong for a consumptive to fondle and kiss a little baby or child on the mouth.

Consumption Is Not Inherited.—No child ever comes into the world with this disease already fastened to him; and yet, inheritance is important in connection with consumption. We can inherit a set of lungs that will develop consumption if the germs are ever put into them. But even then we cannot possibly have consumption unless we get the germ into our lungs. Some men are so fortunate, it seems, that even a fair number of germs can get into their lungs without remaining there. In some way, the lungs are proof against consumption. Others are not so lucky, and as soon as the germs get into their lungs, the germs multiply and cause consumption. These germ-proof men and women are in good health, and their strength is up to the standard. In general, it can be truly said, that it is harder for any man to take the disease when he is strong and in good condition than when he is weak and run down or overworked.

Fig. 30. The feather duster is dangerous and should be replaced by the moist cloth. See Fig. 36.

Children Can Get Tuberculosis or Consumption From Milk.—Grown people do not catch the disease in this way. But cows have consumption, and their milk often contains the germs. Babies and children under five using this milk are likely to get

tuberculosis of the bones, of the intestines, or of the lymph nodes, such as the kernels along the side of the neck. The cow that has tuberculosis may look well. You have probably known people who were the picture of health and yet had consumption. It is likewise with cattle; it is impossible to tell by outward appearances which cows are diseased. The veterinary surgeon can tell, however, by testing the cow. All cows that furnish milk for children's use should be tested by a good veterinary surgeon to see if they have tuberculosis.

Consumption Is Curable.—Consumption is so plentiful in Texas that everyone ought to know something about the treatment and outcome of the disease. Consumption is curable. At the instant these words are being written, the author is seated within six feet of a man that had a severe case of consumption, causing hemorrhages. This was in 1899. He had a good physician who diagnosed his disease before he had it very long. He went out to the country and lived an out-of-door life. He slept out of doors, remained out of doors during the day, rested, ate plenty of good rich food, and in every way did what his physician told him to do. The result was that he regained his weight and strength, and is now back at work again, and has been well for five years. He says that any educated man who wants to can get well of consumption. The disease is curable. There is no question of that. Prof. Irving Fisher of Yale is one of the most enthusiastic public health workers in this country, and he has fought his way through an attack of consumption. He

Fig. 31.—The consumptive should spit in a rag or paper.

is well now and has been for years. Almost every man can point to some friend who has had consumption and recovered.

There are four things to do in order to get well of consumption: first, sleep and live out of doors; second, eat plenty of good food like milk, eggs, light bread, chicken, fish, and things of that kind; third, rest yourself and save your strength, especially if you have fever; and, fourth, keep in touch with a good physician to advise you about any special things that may be needed in your particular case.

Fig. 32.—The rag should be burned to destroy the spit.

How to Prevent Consumption.—If we wish to prevent consumption, we must be sure that the rent houses which we move into are free from tubercle germs. Careful inquiry should be made in all cases before moving into a rent house. Find out if anybody has died there in the last year. If so, do not expect anyone to tell you the deceased died of consumption. Some families do not like to admit that they have had consumption in any of their number. If anyone has died in the house, or if there has been any case of sickness in the house within twelve months, you had best regard it as dangerous and disinfect it. In chapter XVI of this book you will find a description of the best method for disinfecting a room.

Fig. 33.—The rag may be thrown into a disinfectant instead of being burned.

Spitting.—We should all be careful where we spit. Everyone has to spit sometimes, and it is safe to spit in a spittoon or cuspidor, on the ground in a sunny place, provided it is not on the sidewalk, or in a special paper handkerchief or rag carried for the purpose. Those who have tuberculosis should carry rags or paper handkerchiefs at all times, and after spitting in them should burn them. See Sanitary Code for Texas, page 337, Rule 62.

The most important thing a family can do to prevent the spread of tuberculosis is to stop the dry method of sweeping and dusting.

The Duty of the Government.—The city health department in every city should have a map showing the location of each case of consumption, and when any house of a consumptive is vacated, the house should be disinfected before anyone else moves into it. The city should also furnish free printed matter to the poor who have consumption, so that they may learn how to get well, and how to keep from giving the disease to others. The city should have an outdoor hospital, or pavilion, for poor consumptives, as this would prevent them from spreading the germs. Only the larger cities can afford to have a visiting nurse to go into the homes of the poorer consumptives and actually teach them how to take care of themselves and others. All towns should have an inspector to see that the milk sold in the towns is pure. This is especially to protect the babies.

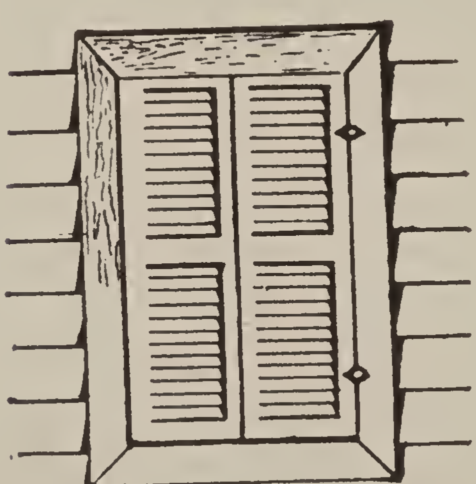

Fig. 34.—The closed window is the friend of the consumption germ, and the enemy of good health.

Important Points.

1. Consumption is the commonest disease on earth, and a large percentage of all people who live to be fifty years old have had consumption at some time in life.

2. Consumption is curable, and a great majority of those who have it recover.

3. Consumption is not hereditary, but is catching; it is spread by a rod-shaped bacterium that is cast off from the body in sputum.

4. Tubercle bacteria can live for months in dark corners of dwellings, and all rent houses should be disinfected before being occupied.

5. Dusting and sweeping by the dry method is one of the ways to spread consumption.

6. Babies and small children should never drink the milk from a tuberculous cow; the only way to be sure a cow is free from tuberculosis is to have her tested.

7. Spitting on the sidewalk is dangerous.

8. The city government should keep a record of all consumptives and disinfect all houses that have been vacated by them.

Questions.

1. What percentage of all persons have consumption? 2. Is consumption curable? 3. How is consumption spread? 4. Describe the tubercle bacterium. 5. Describe the proper method of sweeping a room; of dusting. 6. Give several precautions which tend to prevent consumption. 7. How long can the germ of consumption live in sunlight? In dark corners? 8. What is the danger in moving into rent houses? 9. Where should a consumptive spit? 10. Where should we spit? 11. Is consumption spread by milk? 12. Name some things the city government should do to limit the spread of tuberculosis.

CHAPTER VII.

Colds, Grip and Pneumonia.

There are a great many disease germs that are so harmful to the body that they cause disease as soon as they enter the body. Leprosy and consumption are of this kind. You never can find leprosy germs or consumption germs in a well man. But there are some other disease germs that are not quite so harmful to a strong, healthy man, and they can live in his body without harming him. The man is so healthy and strong that the germs cannot injure him. But if this same man gets wet and chilled, especially when he is hungry and tired, these germs in his body commence to harm him at once. It seems that the germs have been waiting for the man to get weak, so that they can overcome him.

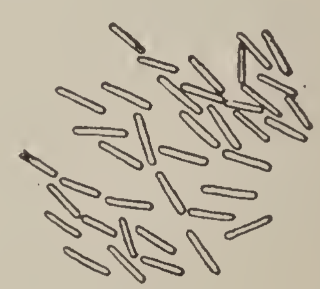

Fig. 35--The germs of grip or influenza.

The Germs of Colds, Grip and Pneumonia Harm Us More When We Are Weak.—The germs which cause colds, grip* and pneumonia are all of this kind. They are very common germs, and almost everyone has some of them in his nose and throat all the time. But they cannot harm us as long as we are in good condition. If we stay out in the open air a great deal, eat plenty of plain, nourishing food, and do not expose ourselves to the weather without proper, warm clothing, the germs are powerless. But if we go hunting in rainy, windy weather and stay all day without eating or resting, or if we get our feet wet, especially when

*Influenza is another name given to grip.

we are tired, the germs may cause a cold or something worse.

Pneumonia Is Especially Dangerous to Drunkards.—In no other disease does alcohol show its damaging effects so plainly as in pneumonia. It is a fact well known by physicians that a drunkard cannot withstand pneumonia as well as one who does not drink. This is one proof that alcohol can act as a poison to the entire system, because pneumonia is not a disease of the stomach, but is a disease of the lungs. Alcohol does not therefore limit its harmful effects to the organs with which it comes in direct contact, but seems to weaken the entire system.

How to Avoid These Diseases.—There are two good ways to avoid grip and pneumonia. The first is to keep ourselves in good condition all the time. We can do this by regular habits of eating and sleeping, working and playing. We can also toughen ourselves by spending a great deal of time in the open air, and by taking cool baths regularly. We should start taking the cool baths in the summer time, not in the winter. We should also start the habit of remaining in the open air in the summer time. Then, as the winter wears on, we can keep it up, within reasonable limits.

Fig. 36.—A moist rag should be used to remove dust.

This is probably the best way to avoid grip and colds, and one good way to avoid pneumonia.

The other way is to try to keep from getting germs from anyone that is sick. It seems that the pneumonia germs from a patient with pneumonia are worse than those we find in people who are not sick. You know, the pneumonia germ does occur

in the noses and throats of healthy people. But these do not seem to be so harmful as the germs from an actual case of pneumonia. The same is true of grip. Many people who seemed strong and well have caught pneumonia and grip by going into the sick room, and, therefore, no one should enter the sick room except for some good reason, and the hands should always be washed afterward. These people have not done anything to weaken themselves, and yet the germs overcame them.

The Value of Fresh Air.—Plenty of fresh air in our living and sleeping rooms helps a great deal in keeping our strength up to the standard. Fresh air also helps the patient who has pneumonia, but this will be looked after by the doctor.

Care of the Hands; Linen; Sweeping and Dusting; Plate, Knife and Fork.—Everybody should know, however, that certain precautions should be taken around any sick room. For instance, the linen from the patient and his bed should not be handled or flirted in the air, but should be carefully bundled up and dropped in boiling water or in a disinfectant solution, as shown in Fig. 24. Those who have to care for the patient should always wash their hands carefully after leaving the room, especially before eating. Dusting and sweeping by the dry method should not be done in the sick room, or in fact in any room. A separate plate, knife and fork should be set aside for the use of the patient, and should be kept separate from those used by other members of the family.

Important Points.

1. The germs of pneumonia, colds and grip are frequently found in the air passages of healthy persons.
2. Exposure to wet and cold weather upsets the body of

these persons slightly and enables the germs to multiply and produce toxins and cause disease.

3. In other instances, the germs of any of these three diseases seem to attack strong, healthy persons who have not been exposed to cold weather.

4. We can avoid these diseases in two ways: first, by keeping ourselves strong, so that the germs cannot overcome us; and, secondly, by keeping away from persons sick with these diseases.

5. In the sick room the usual precautions should be taken, as follows: a separate set of eating utensils should be kept for the patient; the linen should be handled cautiously; dusting and sweeping should be done by the moist method; all persons entering the sick room should wash their hands afterward.

Questions.

1. Name some germs that cause disease whenever they enter the human body. 2. Name some germs which sometimes live in the human body without causing disease. 3. Suppose you have the germs of grip in your system; tell how you could bring on an attack of grip. 4. Does the germ of pneumonia or grip ever act like the typhoid germ, and cause illness in a strong, healthy person? 5. Give three precautions to remember in the sick room. 6. If alcohol is taken into the stomach instead of the lungs, why does it injure the lungs?

CHAPTER VIII.

Meningitis and Diphtheria.

Meningitis and diphtheria are, in some respects, like the diseases discussed in the preceding chapter, for they are due to germs which can live in the human body without causing illness; but the germs of diphtheria and meningitis are not often found in the nose or throat of healthy people; it is more unusual for this to happen than in the case of the diseases treated in the preceding chapter. Diphtheria and meningitis are very contagious and very dangerous.

Diphtheria Is a Dangerous Disease.—Diphtheria caused almost as many deaths in the United States in 1910 as typhoid fever, but in Texas it causes only about a fourth as many deaths each year as typhoid fever. In 1911, diphtheria caused two hundred and eighty-one deaths in this State; diphtheria stood sixth among the communicable diseases as a cause of death.

Fig. 37.—The germ of diphtheria; this germ is cast off from the body in spit and on the pocket handkerchief.

How the Diphtheria Germ Injures the Human Body.—The diphtheria germ lives in the nose and throat. It may cause the mucous membrane to swell and stop up the throat so that the patient cannot get his breath, or the germ may form poisons or toxins in its body. These toxins are absorbed into the blood and may be carried to the brain and stop the heart from beating. It is the toxins made by the diphtheria germs which cause the patient to have fever and flushed cheeks.

Diphtheria Antitoxin Cures if Given Early.—It is indeed fortunate that we have such an excellent remedy against diph-

theria. You have learned in a previous chapter something about how antitoxin is made. The diphtheria antitoxin is made from the blood of a horse that has been specially treated with toxins of diphtheria germs. This serum or antitoxin almost always cures the cases in which it is given early, and for this reason it is well to have all sore throats examined, so that if diphtheria is present, no time will be lost.

Prevention Would Be Better Than Cure.—It may be on account of the fact that we have this excellent cure for diphtheria that so few precautions are taken to prevent the spread of the disease. While the death rate from the disease has been lowred by the treatment with serum, there are still far too many cases of the disease. It would be much better to prevent the disease than to cure it.

How to Prevent Diphtheria.—The most effective way to prevent diphtheria is to isolate all cases of the disease until they are well and the germs have left their throats, for it has been found that the germs live for some time in the throats of patients after recovery. For this reason, wherever possible, an examination of the throat should be made before allowing a patient to go about in public. It is not always practical to do this, however, and the doctor will have to use judgment in letting the patient go.

Fig. 38.—All public towels should be of paper and should be used only once before being thrown away.

Seeing that healthy boys and girls can carry the germs around in their noses and throats without knowing it, it is wise to avoid using the common drinking cup, and the common or public towel. One should also avoid borrowing pencils and things of that kind from others, for many people have the foolish

habit of moistening their pencils in their mouths. The diphtheria germs do not multiply outside the body, except when some careless person allows them to get into milk. They always come from the human body.

Meningitis Is an Inflammation of the Coverings of the Spinal Cord, and it is due to a little oval germ which lives in the nose and throat and spinal canal of those who are sick. We call this little germ the "meningococcus," and as you can see in Fig. 39, it occurs in pairs. You can see in the picture that the white cells of the blood have swallowed some of the meningitis germs.

Fig. 39.—White blood cells containing meningitis germs.

Epidemic Meningitis Is Due to a Little Oval Germ.—The spinal cord is composed of nerves and nerve cells, and is almost like a part of the brain, as you will see later. It is well protected by tough coverings, and it is on these coverings that the meningitis germ especially likes to live. The germ causes inflammation of the coverings of the cord. It is not the only germ which can live in this position and cause this inflammation, but it is the only germ which causes these symptoms in epidemic form. It seems that the meningitis germ has a preference for this location, and does not cause disease elsewhere in the body. When other germs attack the coverings of the spinal cord it is almost always in the course of a spell of sickness in which other parts of the body are affected also; the typhoid germ, for instance, can affect the coverings of the cord and in a sense cause meningitis, but the typhoid germ never causes epidemics of meningitis.

Healthy Persons Sometimes Carry the Germs of Meningitis.—It seems altogether probable that the germ of meningitis can live in the nose and throat of a healthy individual without

causing any inconvenience. From this person's throat the germ can spread to other people and cause meningitis.

The Meningitis Germs Enter Our Body Through the Nose and Mouth.—For this reason all those who have been close to a meningitis patient should be very careful, for they may be carriers of meningitis, although they are not sick.

Value of the Serum Treatment of Meningitis.—Before the introduction of the serum treatment of meningitis, almost all persons who had it died; and those who did not die were usually blind, crippled or otherwise injured. Since this treatment commenced to be used, more than half the patients recover, and it is rare to find any serious defects as a result of the disease. Even now, however, meningitis is one of the most dangerous diseases known. Probably it is the most dangerous epidemic disease that ever affects our country.

How to Prevent Meningitis.—The best measures to prevent meningitis from spreading are the isolation of the sick, and the use of sprays in the nose and throat to destroy the germs. All those who have been around a case of meningitis should keep their throats sprayed out in order to protect themselves as well as others; for one who feels perfectly well can carry the germs and spread the disease.

Certain other germs can cause meningitis but not in epidemic form.

Important Points.

1. Diphtheria is a dangerous contagious disease of the nose and throat, and is due to the diphtheria germ.

2. The diphtheria germ itself does not spread over the body, but its toxins do, and the toxins cause the fever and other symptoms of diphtheria.

3. Diphtheria can be cured by the serum or antitoxin, if it is used early.

4. The secretions from the nose and throat contain the diphtheria germ, and therefore public drinking cups and public towels are dangerous.

5. Meningitis is the most dangerous epidemic disease which occurs in our State.

6. It is due to a germ which lives in the coverings of the spinal cord, and also in the nose and throat.

7. Meningitis is spread in the same manner as diphtheria, by secretions from the nose and throat.

8. In both diphtheria and meningitis the germs can live in the nose or throat of a healthy person without causing inconvenience.

9. The serum treatment of meningitis has cut in half the death rate from this disease.

10. If there is no other way to save life, animal experiments are just and right.

11. Diphtheria and meningitis are prevented in the same way: isolate the sick; avoid handling articles like public drinking cups and public towels; remember that healthy persons may be disease carriers.

Questions.

1. Where do the germs which cause diphtheria and meningitis enter our body? 2. How does the diphtheria germ injure us? 3. What is a diphtheria carrier? 4. What is the cure for diphtheria? 5. Explain how the common drinking cup spreads diphtheria. 6. What is the most dangerous epidemic disease which occurs in Texas? 7. Where does the meningitis germ enter the human body? 8. What is the cure of meningitis? 9. What symptoms formerly followed meningitis if the patient recovered? 10. Would it be dangerous for the nurse in charge of a meningitis patient to mingle in a crowd of people? Why?

CHAPTER IX.

Malaria, Yellow Fever and Dengue.

Malaria, or "chills and fever," is just as definite a disease as measles, and we know more about it than we know about measles. We know the little germ that lives in our bodies and multiplies, causing malaria; its name is the malarial parasite or plasmodium of malaria. The little germ cannot live anywhere in the world except in two places: first, in certain parts of the human body, especially in the blood; and, secondly, in a certain variety of mosquito. And the malarial germs cannot even live in all parts of the human body. For instance, if we accidentally swallowed or breathed in some of the germs they would not live, but would die in our bodies, and hence would do us no harm. If we drink water containing the "wiggle tails," which are only young mosquitoes, it cannot cause malaria. In fact the malarial germ is a very particular little germ, and if it cannot enter our bodies just as it likes, it cannot live, but dies quickly.

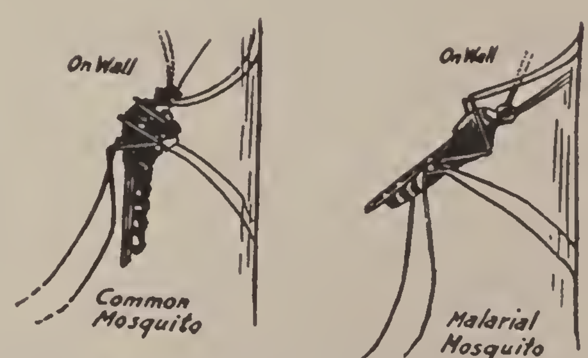

Fig. 40.—Observe that the malarial mosquito stands out from the wall.

How the Germ Enters Our Bodies.—How then does the germ of malaria get into our body? It comes in through the mosquito's "bill" when she bites us on the skin. And that is the only way it ever enters our bodies. Now, it is strange, but true, that a malarial patient cannot give malaria to anyone else unless the mosquito acts as a messenger or car-

rier to others. In other words, if one member of the family has malaria, it is perfectly safe for him to remain in the same room with the others, so long as he uses a mosquito bar or net to keep the mosquitoes from reaching him.

Proving That Malaria Is Spread Only by the Mosquito.—The first man to prove that the germs of malaria grow and develop in the mosquito was Dr. Ronald Ross of England, who made this discovery on August 29th, 1897. Two years later our U. S. Army Commission proved at Havana that yellow fever also is spread by the mosquito, and in no other way. In Chapter III, you have already learned that Dr. Carroll and Dr. Lazear lost their lives while making these investigations. This was in 1900. The same year Dr. Wm. Thayer of Baltimore and Dr. Albert Woldert of Texas demonstrated that in this country the Anopheles mosquito harbors malarial parasites and by injecting them into man, spreads chills and fever.

Fig. 41.—The malarial mosquito, called "Anopheles." This mosquito stands out from the wall when it alights, as shown in Fig. 40.

While our American scientists were making these brilliant discoveries, Drs. Sambon and Low of London spent the summer in the Italian Campagna Swamp, near Rome, where almost everyone had malaria during the summer. These gentlemen, however, slept behind mosquito-proof screens, and as you will imagine, they remained free from malaria.

Where the Mosquito Gets the Germs.—But we must not forget one thing: the mosquito is harmless unless she has previously bitten a patient sick of malaria. We say, mosquitoes carry malaria from one man to another. If the mosquito could

think and talk, she might say, "Human beings carry malaria from one mosquito to another." One man cannot give malaria to another without the mosquito, who acts as a messenger or carrier. The mosquito is fond of human blood. She thrusts her bill down into the skin of a malarial patient deep enough to suck out some of the blood, together with the malarial germs present in this little drop of blood. The malarial germs multiply in the body of the mosquito. Then later, when she bites some other human being, the germs leave her through her "bill" and enter the body of the unfortunate human being, who then becomes sick with malaria.

Prevention of Malaria.—When we limit the number of mosquitoes, we prevent malaria. The best method of eliminating the mosquitoes is to kill the wigglers by pouring oil over the water in which they live, or, better still, to do away with all standing water, as is fully discussed in Chapter XIV.

Fig. 42.—Note that all doors and windows are screened and that the upstairs porch is entirely screened in. This house is safe from malaria in any climate.

Screens Will Prevent Malaria.—There is something, however, which we can all do that will almost surely protect us from malaria; that is, to screen our homes. In Texas we have such a delightful climate and so little really cold weather that we need screens all the year round to protect us from insects. Copper or brass wire screens are most durable but expensive. Galvanized iron wire screens are next best. Ordinary wire screens do not last long. All the screens should be fine meshed, so as to keep out all small mosquitoes, too. The variety of screen that has sixteen

meshes to the inch is best. Mosquitoes easily crawl through the twelve mesh screens, or through mosquito bars with coarse mesh. Mosquitoes may also be driven out of the house by burning certain things in a room, so as to cause a dense smoke, as, for instance, chips, leaves, or pieces of old cotton cloth. The fumes from burning sulphur or insect powder will kill mosquitoes. Whenever sulphur is burned indoors, it should be borne in mind that the fumes, if inhaled, are irritating and dangerous. Burning sulphur also has a tendency to sputter, and in this way leap out of the bucket or tub and set fire to the house. Of course, the fumes of sulphur will tarnish metals, and hence metal articles of value should be taken from the room before fumigating with sulphur.

Old-fashioned Ideas.—Malaria cannot be spread by damp air or by the beautiful mists which rise over the swamps and may be seen early in the morning. A home in the swamps or river bottoms can be rendered perfectly safe from malaria by screens and mosquito bars or netting; for malaria is a disease that is spread in one way, and only one, and that is by the mosquito.

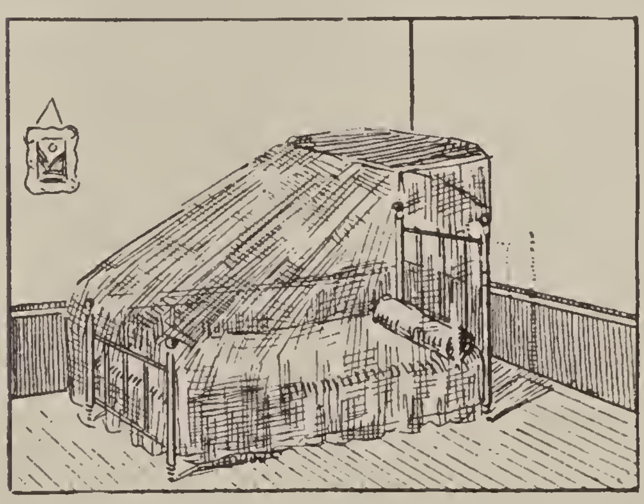

Fig. 43.—A mosquito bar can always be procured, and it is the next best thing to a screened room.

Other Diseases Spread by the Mosquito.—There are two other diseases which are also carried by the mosquito, namely yellow fever and dengue fever.

Each Disease Is Spread by a Separate Kind of Mosquito.—It is remarkable that only certain kinds of mosquitoes can

carry these diseases, and a certain particular kind of mosquito carries each separate disease. One kind of mosquito, called Anopheles, carries malaria; another kind, called Stegomyia, carries yellow fever, and another kind, called Culex, carries dengue. The pictures show the three kinds. But, remember, the mosquito cannot carry the disease unless she has bitten some one sick of the disease.

Yellow fever is a very fatal disease, and in olden times it was much dreaded by people in Texas, because when it occurred in epidemics it would kill many people. The people thought it was due to ''something in the atmosphere,'' or 'something that blows up from the swamps.'' They were right, for that ''something'' was simply a mosquito. Nowadays we know how to stamp out the disease because it cannot be carried in any way except by the mosquito. Yellow fever is not so much dreaded now as it was formerly. And yet, we are so close to Mexico and Cuba and Brazil that once in a while some ship will steam into our Texas ports with yellow fever on board. When this occurs we can prevent the spread of the disease by killing all mosquitoes on board. It does no good to quarantine against yellow fever, because you cannot quarantine against the mosquito. And if a yellow fever patient enters town he could not give the disease to any one if he tried except by mosquitoes. Of course, if a town does not rid itself of mosquitoes, then a quarantine is needed.

Dengue is an unpleasant disease to have, but not a dangerous one. About every ten years it tries to get a foothold in Texas, and sometimes it sweeps all over those parts of Texas where mosquitoes are most abundant. It has occurred so many times while there was also an epidemic of yellow fever, that some people formerly thought it was kin to yellow fever. It is an entirely different disease, however, and an attack of yellow

fever does not protect one from dengue. There were thousands of cases of dengue in Texas in the late summer and fall of 1907, and the disease did a great deal of harm by leaving people weak and nervous, and also by frightening them. To prevent another epidemic, each city and town should have a health department to destroy the breeding places of mosquitoes. All homes in Texas should be screened also.

Fig. 45.—Culex, or ordinary mosquito, which spreads dengue.

Important Points.

1. Malaria is due to a germ which lives half its life in the blood of a malarial patient and the other half in the body of a certain kind of mosquito.

2. Malaria will disappear from Texas when all our people commence using screens and mosquito bars.

3. Yellow fever and dengue fever are also spread by the mosquito, but each one by a different kind of mosquito.

4. Only the female mosquito bites man.

Questions.

1. What connection has malaria with the location of a house? 2. Name two places where the malarial germ lives. Does it live anywhere else? 3. Suppose you should swallow the eggs of a mosquito, would you be likely to have malaria? 4. If you drink water from a cistern in which there are wigglers will it give you malaria? 5. Suppose you were bitten by a hundred mosquitoes, none of which had bitten a malarial patient, would you contract malaria? 6. Name two other diseases caused by mosquitoes.

CHAPTER X.

Quarantinable and Reportable Diseases.

One very old method of limiting the spread of a communicable disease is by **quarantine.** The word quarantine is from an old Italian word meaning "forty," and refers to the number of days ships were held if they contained people sick of contagious disease. Today the word quarantine usually means confining people to certain premises or places to stop the spread of communicable diseases.

Fig. 51.—Nurse under quarantine. Note the sheet over door.

Modern Quarantine— Our ideas of quarantine have changed as we have learned more about the cause and spread of diseases. For instance, in smallpox, we still hold the patient in quarantine a certain number of days after he recovers from smallpox; but in diphtheria, as you have learned, the germ can live in the throat for some time after the patient recovers, and so we do not keep the patient for a definite number of days, but keep him until his throat is free from diphtheria germs. Sometimes this is a few days after the attack is over, and sometimes it is six months. For this reason many people are allowed to go free sooner than they otherwise would have been, because their throats contain no germs; but other patients are kept much longer

than formerly, because if permitted to go about in public they would be dangerous to the public health.

While this is so, we still have to rely on a definite time limit in many diseases. The following diseases are declared by law to be quarantinable in Texas: Asiatic cholera, plague, typhus fever, yellow fever, leprosy, smallpox, scarlet fever, diphtheria (membranous croup), epidemic cerebro-spinal meningitis, dengue, typhoid fever, epidemic dysentery, trachoma, tuberculosis and anthrax (charbon). (See Sanntary Code, Appendix B).

The length of time patients are held varies with the different diseases, and depends on the length of time such patients continue to be contagious after the recovery from the illness.

People Who Have Been Exposed to a Disease May Be Quarantined.—Sometimes well people are quarantined because they have been exposed to a disease, and it is feared they may develop the disease. In this case the length of time they are kept under quarantine depends on how long it takes the disease to develop after one has been exposed. This period, while the disease is developing, is called the **incubation period,** from the fact that the germs are being incubated in the body. After the germs are introduced it takes them several days usually to multiply sufficiently to cause symptoms of disease. Even before symptoms develop, however, such patients can convey the disease to other people.

Reportable Diseases.—We should especially note that the law requires reports to be made and complete records to be kept of all quarantinable diseases, including typhoid fever and tuberculosis. The physician in attendance on these cases is required by law to report them to the local health officer; the latter reports them to the State Board of Health, and both the local and the State health officers keep a record. The records of cases of tuberculosis are required by law to be kept pri-

vately, and no one except the proper authorities have the right to see them. This is done because no outsider has any right to know what a patient is suffering from except the officers of the law who are protecting the public health. At this time there are so few cases of these diseases in many communities in Texas that complete records are not kept. As our State grows, however, it will be more and more necessary to observe the law, and we need improvement in this regard even now. Investigate and see if these diseases are reported in your community. If they are not, make up your mind to do your part in future and get them reported.

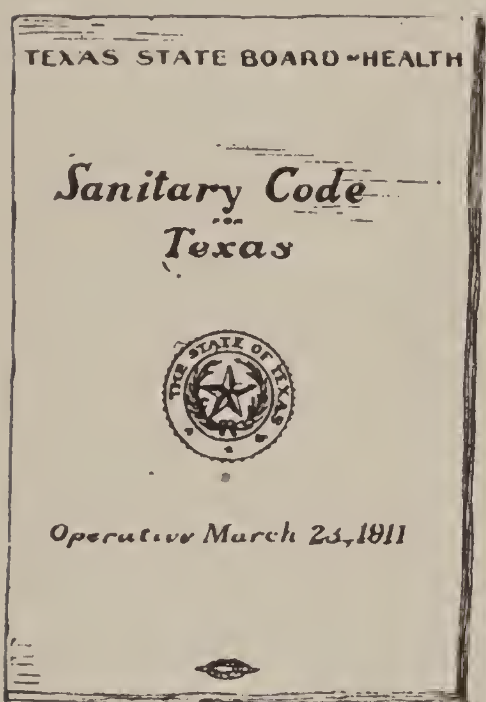

Fig. 52.—This code is the Law in Texas. (See page 337.)

The Sanitary Code Will Be Sent to Your School.—The State Board of Health at Austin will take pleasure in sending to your school a copy of the Sanitary Code, containing many of the legal rules concerning quarantine and health matters generally. It would be well for each class to get a copy of this, as it is the law of the land. Is it well enforced in your town or county? Good citizens should be willing to submit to quarantine whenever they have a communicable disease, even though it be in a mild form; because fatal cases may arise from very mild ones. The Sanitary Code for Texas is given in abbreviated form in Appendix B, page 337, of this book.

Flagging the House.—As a rule, quarantine consists in keeping the sick individuals in a certain room or house, and preventing any one from entering or leaving this room or house

except the nurse and physician, who take pains not to convey the disease. A placard is tacked upon the house warning the public not to enter, or a yellow flag is placed on the house.

Elsewhere in this book you have learned what the following diseases are and how they are carried from one patient to another: Asiatic cholera, plague, yellow fever, diphtheria, dengue, meningitis, typhoid fever, tuberculosis, trachoma and anthrax (charbon). We will take up in order the following communicable diseases, namely: typhus fever, leprosy, smallpox, scarlet fever.

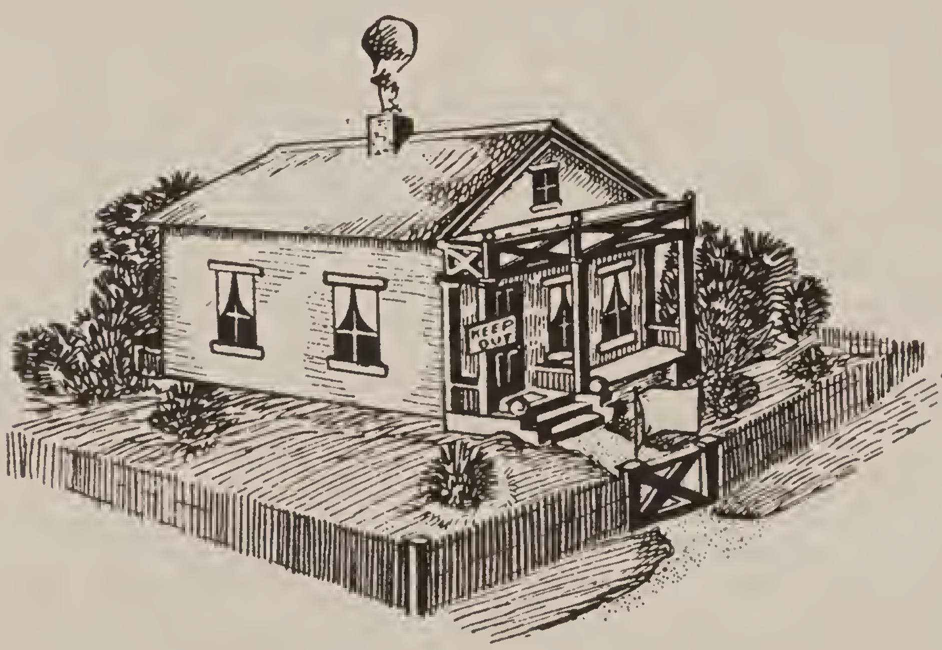

Fig. 53.—A house under quarantine. The sign on the porch is usually omitted. The flag is red or yellow.

Typhus fever is another name for jail fever, or ship fever, and is not closely related to typhoid fever. It exists at all times in Mexico, and is found in unclean houses. It is carried by certain insects that live in the clothing or hair of uncleanly people. These insects are called body lice, or head lice. It is not likely that this disease will gain much foothold in Texas.

Leprosy is a very old disease, and one that is very terrifying to most people. It is due to a germ that resembles the tuberculosis germ, and is found in the sores and in the

secretions from the nose of lepers. It is not likely to attack many people in Texas.

Smallpox is a dangerous disease that causes fever and little pus pockets or **pustules** all over the skin of the body. It is one of the most contagious diseases known, and a high percentage of those exposed take the disease.

In Fig. 14 you have seen the picture of a little baby with smallpox, and a very dismal picture it is. Up to this time, the germ of smallpox has never been proved to have been discovered, but, fortunately, this is one disease which we know how to prevent. Vaccination is a sure preventive of smallpox.

Scarlet fever is just another name for scarlatina. There is no difference between the two. This disease is very contagious, and the garments of a scarlet fever patient retain their power to cause the disease in another child for many months. Up to this time we do not know the nature of the germ that causes scarlet fever, and so we can do very little to prevent the fever except to quarantine all scarlet fever patients. The greatest care is necessary in destroying or disinfecting all toys, clothing and other things of this kind that have been in the room with a scarlet fever patient.

Diseases Which Exclude Children From School.—There are several diseases that affect children especially, and which are so mild that a quarantine is not considered necessary. These diseases are measles, mumps, whooping cough and chicken pox. These diseases are alike in that they attack a large percentage of all children in this country. If one escapes these diseases, however, and grows up, he may have the disease after he is grown. They are all more or less mild, as a rule, and do not kill a high percentage of those affected. Owing to the fact that so many people have them, however, these diseases are very important. For this reason pupils are debarred

from school while sick with either of these four diseases mentioned.

Measles is by far the most important of these diseases. It causes every year about six thousand deaths in the United States. In Texas alone two hundred and twenty-two deaths from measles were reported in 1911.

Recently it has been noticed that measles is more fatal among children from six months to five years old than among boys and girls from five to fifteen years old. This would lead mothers to be careful to prevent their children from having measles before they reach the age of five or ten. It is not uncommon to hear mothers say that they want their children to have measles and get through with it. But this is not wise, for measles is a serious disease, especially among little children.

Whooping cough is also a serious disease when it attacks babies and very young children. This disease is due to a definite bacterium that resembles the grip germ. The whooping cough germ cannot easily be carried in the clothing, but is usually spread from one child to another by direct contact between the

Fig. 54.—Little children should not be allowed to mingle on the street with other children, as whooping cough and other diseases are caught in this way.

children. For this reason it is not hard to ward off whooping cough. Simply keeping babies away from other children except those known to be healthy is all that is needed. Whooping cough, measles and scarlet fever each cause about the same number of deaths each year in the United States. Of course, measles is the mildest of the diseases, and scarlet fever is the severest.

How These Diseases Are Spread.—In each of these diseases, it is true that some solid or liquid particles must pass from the body of the sick into the body of the well before the disease can spread. In these instances the particles are especially the little droplets of saliva that fly out of the mouth when the patient coughs or speaks. In measles and scarlet fever it may be that the dried particles of skin that scale off are concerned in the spread of the disease. The germ of measles and scarlet fever have never been found, and it is possible that they are so small that they are invisible with our strongest microscopes. You have already learned that some germs are so small that they cannot be seen at all, as, for instance, the germ of rabies or hydrophobia.

Important Points.

1. Quarantine is an old-fashioned method of preventing the spread of disease, and in some cases we have learned a better way; but in many cases we still have to resort to quarantine till we have found out exactly how the diseases are spread.

2. The laws of Texas declare that the following diseases are quarantinable: typhus fever (not typhoid), Asiatic cholera, plague and yellow fever, smallpox, scarlet fever, diphtheria (membranous croup), dengue and leprosy.

3. The following diseases are quarantinable only to the

extent that they debar pupils from school: measles, mumps, whooping cough and chicken pox.

4. The contagion of smallpox and scarlet fever, that is, the little particles thrown off from the patient's body, live for many months and retain their power to cause the disease.

5. The contagion of measles and that of whooping cough do not live over two weeks, as a rule, but these diseases are dangerous to small children and babies.

Questions.

1. What is the old or original meaning of the word quarantine? 2. Why do we not hold all dangerous contagious cases exactly forty days now? 3. Name three quarantinable diseases that have occurred in your community. 5. Name two quarantinable diseases in which the contagion will live a long while on clothing. 6. Is it wise for mothers purposely to expose little children to the measles? 7. How many deaths occurred in Texas in 1911 from measles? 8. Name three diseases that should exclude pupils from school, but which are not of sufficient importance to require a full quarantine. 9. What is the best way to prevent whooping cough in babies? 10. Why is it important to postpone the attack of whooping cough till the child gets older? 11. How can you get a copy of the sanitary code?

CHAPTER XI.

Pellagra and Hookworm Disease.

A great deal of attention has been paid in recent years to hookworm and pellagra, two diseases that may be called new in the United States.

Pellagra, a Disease of Unknown Cause.—In Texas more attention has been paid to pellagra than to the other, although hookworm disease is probably more prevalent and certainly more easily surable than pellagra. Not knowing positively the cause of pellagra, we can do nothing to prevent it. It is not very catching, if at all, and yet we ought to be careful about stating that it is not catching till we know more about the cause. It certainly seems, however, that it does not spread by contagion, at least in hospitals. No precautions have usually been taken to prevent its spread, and yet in this State no case has ever caused a second case among the nurses or physicians and others who have cared for the patients. At the same time, there have been several families in which more than one case occurred. The main symptoms of pellagra are sunburn on the back of the hands, the face and neck, with diarrhoea, and nervousness. Many cases of pellagra get well, and if medical attention is sought early, no one should be discouraged on account of this disease. A change to a cool climate is probably beneficial.

Hookworm Disease Is Present in Texas.—Hookworm disease is not uncommon in the thickly settled parts of Texas, especially in the sandy soils of East Texas. It is a curable and preventable disease.

The Hookworm That Causes This Disease Lives in the Small Intestine, and Sucks Blood From the Intestinal Wall.—The dis-

ease shows itself especially by the lack of blood which is observed in those who have it. These people who have hookworm disease are usually pale, weakly and stooped. They lack energy and strength. They are often nervous and have fickle appetites. But, after all, no especial symptom is caused by the hookworm that is not caused also by other diseases causing weak blood.

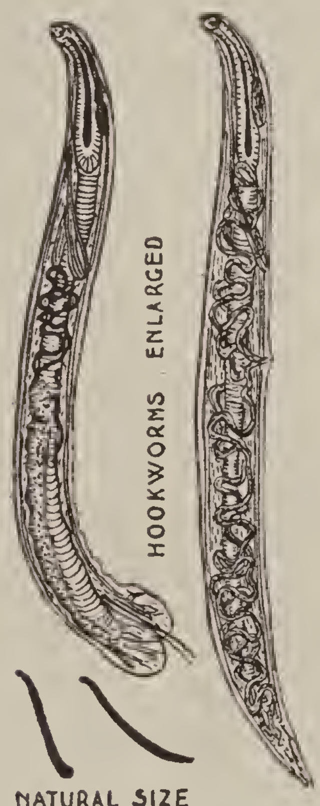

Fig. 49. Male and female hookworm

The Only Way Surely to Know Whether Anybody Has Hookworm Is by the Use of the Microscope.—The worms lay eggs, and these eggs leave the intestines in the waste matter that is thrown off from the body. The eggs are too small to be seen with the eye, unless the microscope be used.

The hookworm itself is a small worm about a half inch long, and it remains in the intestine. The eggs, however, pass out, and are dangerous, as they cause the spread of the disease. Just how the eggs hatch out and get into man's body is a wonderful story. It almost surpasses belief, but we are forced to believe it, because there are actual photographs showing the worm in all the stages of its journey from one man to another. The egg hatches soon after it leaves the body or intestines of the patient. A little worm is formed from the egg. This worm gets on the skin of children, especially those that go barefooted, and goes into the skin, causing a little blister where it enters. This blister is known as the "ground itch." We know now that ground itch is nothing but one stage in hookworm disease. The worm passes through the skin and gets into a blood vessel. It passes up the blood vessel to the lungs. Here it eats its way

through the blood vessel wall and gets into a bronchus, or bronchial tube. The worm squirms along the bronchial tube and gets to the windpipe and then to the throat. It then turns back down the throat and passes through the stomach into the intestine, where it commences its usual life. It is probable that some hookworm eggs are swallowed directly, and hatch in the stomach or intestines.

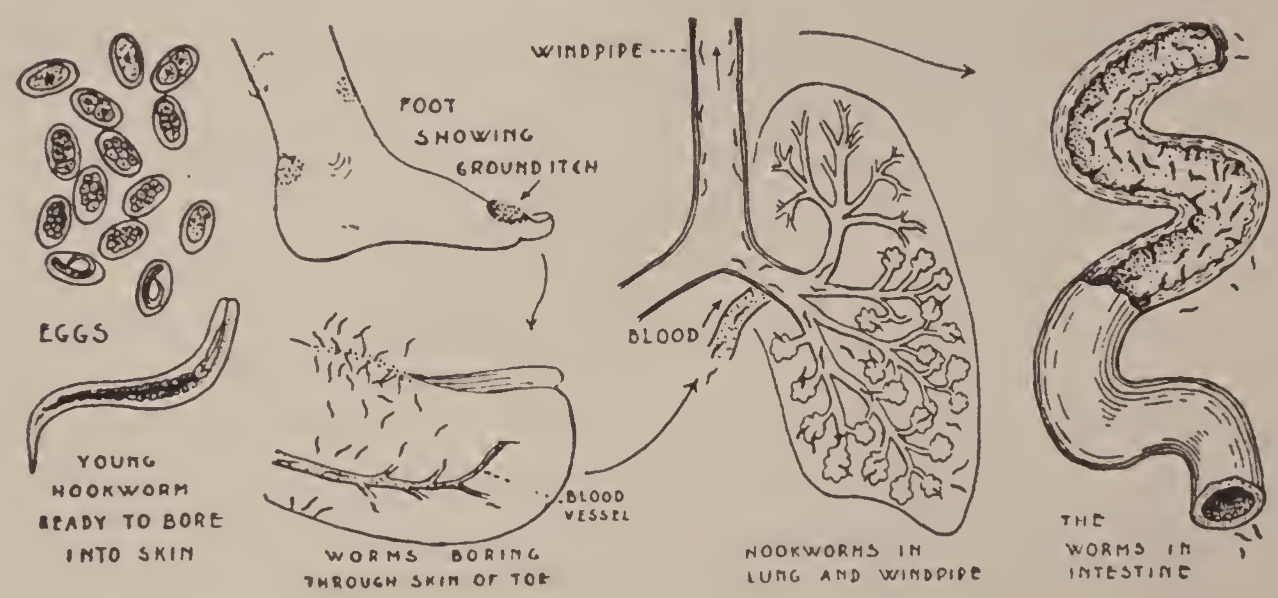

Fig. 50.—The hookworm eggs hatch into little worms which penetrate the human skin, enter a blood vessel, pass to the lungs, enter a bronchus, crawl up the windpipe, are swallowed, and thus reach the small intestine.

Soil Pollution Is the Important Thing in the Spread of Hookworm Disease.—Unclean wastes from the body are allowed to be poured out on the soil. The ground then is not only unclean, but is dangerous, because a child walking along barefooted is likely to become sick first with ground itch and then with hookworm disease. Such children are backward in their growth, stunted and weakly. They are not well, and do not play and study like healthy children.

Sewers and Sanitary Outhouses Are Needed.—The best preventive of soil pollution is a good sewer system, but this

cannot be had on the average farm. The next best thing is well built outhouses. A picture in the back of this book shows a poor and a good kind of outhouse.

No wastes from the human body should ever be allowed to be thrown on the ground, as there are too many diseases which may spread in this way. People who do not know they have any disease may scatter disease germs, for they may be disease carriers.

Other Intestinal Worms that cause disease in man are the tape worms and round worms. They are spread in a peculiar way. The eggs of the tape worm leave the body as in the case of hookworm. But these eggs of the tape worm then get into the body of the hog or beef or fish, where they hatch into young worms. When we eat the flesh of these animals, if it is not well cooked, the young worms commence their life in our intestines. All meat should be inspected carefully by a meat inspector, and it should be well cooked to prevent the spread of tape worms, and other diseases.

Thymol Is the Remedy for Hookworm, but as it is not a harmless drug, it should be employed under the advice of a physician. No oil of any kind or butter should be taken after taking thymol.

Important Points.

1. Pellagra is a disease rather new in America, but fairly well distributed over the Middle and Southern parts of the United States.
2. We do not know the cause or the nature of the disease.
3. Pellagra is often curable, and a cold climate seems to have a beneficial action.
4. Hookworm disease is due to the presence in the small

intestines of small worms about half an inch long, which attach themselves to the wall of the intestines and probably suck blood.

5. We know how to prevent and cure hookworm disease: it can be prevented by preventing soil pollution from body wastes; and it can be cured by small doses of thymol.

6. The small hookworms, just after they are hatched, can pass through the skin and find their way by a complicated route to the small intestine, which is their home.

7. The sanitary outhouse, built according to the directions given in the back of this book, will prevent the spread of hookworm disease.

Questions.

1. Do we know the cause of pellagra? 2. What is the cause of hookworm disease? 3. Where do the hookworms live in the body? 4. What symptoms do they cause? 5. Where do the worms enter the body? 6. Describe their journey from the skin of the feet to their final home. 7. What is the most effectual way to prevent the spread of hookworm disease? 8. Is there a cure for the disease? 9. In what kinds of meat are we likely to find tape worms?

CHAPTER XII.

Bubonic Plague.

When the Panama Canal is opened, Texas will be in much closer connection than ever before with China, India and the Eastern countries generally. It is possible that some of their cases of bubonic plague may stray into our ports, and start a focus of the plague in our State. We should know that the disease is spread by rats and squirrels, so that we can protect ourselves intelligently.

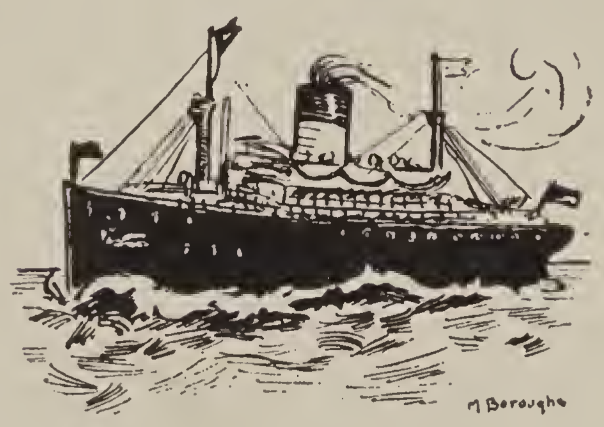

Fig. 46. Ships from foreign countries might bring bubonic plague into our seaports.

Plague Affects Animals as Well as Man.—Plague, or bubonic plague, as it is called, is one disease that man shares with lower animals. It is due to a germ that lives in the lymph nodes, in the lungs and in the blood. The disease is a very fatal one. It kills a high percentage of men that have it and also kills many rats and ground squirrels. There is a plague center in California at the present time. Only squirrels and rats are affected there at present, but now and then some hunter catches the disease from squirrels.

Fig. 47. Plague affects squirrels.

Plague is also distributed in some of the South American

countries, and some of them are so busy fighting each other that they have no time to fight the plague, and hence some plague will remain there.

Plague Is Spread by the Flea.—The interesting thing is that it is the squirrel flea that conveys the disease. The huntsman kills a squirrel and picks him up. The fleas leave the dead squirrel as he gets cold and get on the man and bite him. The man develops the disease.

Rats Are Objectionable.—Rats are dangerous on account of other diseases as well as plague, and they are very expensive. It is wise to make all premises as nearly ratproof as possible. This can be done in the following way: Wooden walks should be torn up and replaced by concrete or gravel. The residence should be at least eighteen inches up above the ground, measuring from lowest joist. The barn and chicken yard should have concrete floors, and chicken wire of small mesh (1-2 inch) should be used. The woodshed should have no floor, and the wood should be piled on platforms at least two feet high. Garbage should be kept only in iron cans with close fitting lid. All grain should be stored in a metal ratproof container.

Fig. 48. Rats spread plague.

If the premises are ratproof a little poison will kill off all the rats, because there will be nothing ese for the rats to eat but the poison.

In case plague should occur in Texas, quarantine would not do much good. The rat and ground squirrel would be the point of attack.

Important Points.

1. The Panama Canal will bring Texas in close touch with the Eastern countries like China and India.

2. Plague is epidemic in the East, and hence it may enter Texas.

3. Plague is spread principally by the fleas which are found on rats and squirrels.

4. In case plague should break out, we could probably get it under control soon, but after it gets a start among the rats and squirrels it is a very difficult matter to exterminate it.

5. The proper way to guard against plague is to exterminate the rat, and if necessary the ground squirrel.

6. As you will see from Rule 3, Texas Sanitary Code, page 337, bubonic plague is a contagious disease.

Questions.

1. How is bubonic plague spread? 2. What countries are afflicted with plague today? 3. In what State of the United States has plague existed and among what animals? 4. How could we prevent the spread of plague if it should appear in one of our seaports?

CHAPTER XIII.

Disease Carriers.

You have learned that in several ways it is possible for a well man to have disease germs in his throat or elsewhere in his body. This is particularly true of typhoid fever, diphtheria, meningitis, pneumonia and grip. We call these people who walk about carrying these dangerous germs, "germ carriers," or "disease carriers." It is hard to believe this kind of thing is possible, but we must believe it, for many reliable men, and men of good judgment, have investigated, and they say it is true. It is easy to prove.

Typhoid Carriers.—In the case of typhoid fever, the carriers are usually people who have had the disease a year or two before. By carefully examining all who have had typhoid fever, certain scientists have found that some healthy men have the typhoid germ in their intestines, or in their kidneys. It has been proven to be the true typhoid germ. Many people have caught typhoid fever from these carriers, who were proven to have typhoid germs in their bodies.

Fig. 55.—A typhoid carrier handling milk is very dangerous.

Gallstones are often due to typhoid fever. That is, one of the after effects of typhoid fever is gallstones, and the gallstones may not be noticed for years after the typhoid fever. But if people with gallstones are examined they are often found to be typhoid carriers.

Dr. Robert Koch, the great scientist, who discovered the bacterium of tuberculosis, said that if the typhoid carriers could be prevented from spreading typhoid fever, the disease could be stamped out. The particular danger with typhoid carriers is that many of them are cooks, bakers, dairymen and the like. One typhoid carrier in New York was a cook and caused twenty-six cases of typhoid in seven different families.

Diphtheria Carriers.—It was a surprise to many doctors when it was found that the diphtheria germ could live in the throat of a healthy boy or girl without setting up the disease. This fact, however, is well proven, too. The right way to apply a quarantine to a family that has had diphtheria is to examine the throats and let them go free as soon as their throats are found free of the diphtheria germ. The same is true of meningitis.

Fig. 56.—A diphtheria carrier.

Meningitis Carriers.—Meningitis is such a deadly disease, especially when not treated by serum, that it seems almost unbelievable that the meningitis germ should live in anyone's throat without making him sick. But this is most certainly true. And this explains why people fall sick with meningitis when they have never been near a meningitis patient. Without knowing it they have been near a meningitis carrier.

Two Lessons.—There are two lessons to learn from these germ-carriers: First, we should note how perfectly the human body can protect itself against germs, even when the germs are actually living in the body; secondly, we should remember that uncleanly habits are dangerous, even when there is no

sickness about, for people who appear healthy may be scattering deadly germs every day.

Important Points.

1. Some disease germs are so harmful that they invariably cause disease whenever they live in the human body; the germs of leprosy are of this kind.

2. Other disease germs usually cause disease when they live in the body, but some persons are so resistant that the germs can live in their bodies without causing disease.

3. A healthy person who has disease germs living in his body is called a disease carrier.

4. Other people may be killed by the disease germs which are harmless to the disease carrier.

5. Typhoid fever, diphtheria and meningitis are spread by carriers.

6. Persons have been known to carry the typhoid germs for years after recovering from the fever.

7. Typhoid carriers are especially dangerous when they work in dairies or other places where food is handled.

8. It is impossible to tell whether a typhoid convalescent is a carrier except by a laboratory examination for the bacteria.

Questions.

1. Name three diseases spread by carriers. 2. Can you tell a typhoid carrier by his appearance? 3. How do you explain the fact that the germs in a disease carrier do not make him sick? (See Chapter IV.) 4. In what occupations are disease carriers most dangerous to the public? 5. How can disease carriers be discovered? 6. Suppose you catch typhoid fever from a carrier or from a mild case, is your case likely to be mild?

CHAPTER XIV.

Insects Which Scatter or Carry Disease.

The important fact has often been pointed out in these pages, for instance in Chapter IX, that disease germs are derived from the bodies of persons who are sick. The germs of disease are carried from the sick to the well in various ways: in the air, in clothing, by insects, by means of drinking cups and towels, by contact, in our food and our drinking water. In this chapter we shall learn how the house fly carries typhoid and other germs to our food, and how blood-sucking insects transfer the germs of certain diseases from the blood of the sick into the blood of the well, thereby scattering and causing disease. Mosquitoes are responsible for scattering yellow fever, malaria, dengue fever and several other terrible diseases. Ticks spread disease among men, among cattle, and among chickens. Whereas formerly it was considered remarkable that a disease should be conveyed from one person to another by insects, we now consider it almost a rule that any insect which lives on the blood of any animal is likely to convey disease from one of those animals to another.

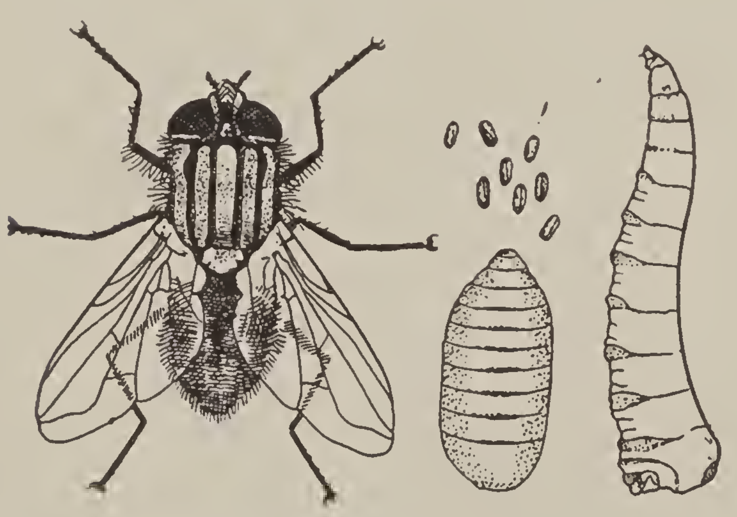

Fig. 57.—This picture shows the eggs of the fly, and then the larva and pupa which the egg changes into before it finally becomes a grown fly. The larva is called a maggot.

THE HOUSE OR TYPHOID FLY.

Description of the House Fly.—The house fly may be called one of our domestic animals, for it occurs almost exclusively about the habitations of man. Since it cannot bite like its "cousin," the stable fly, it has until recently been considered perfectly harmless. It is, moreover, a rather pretty creature, with symmetrical body, a pair of gauzy wings, compound eyes and agile habits.

Fig. 58.—The foot of the fly.

In connection with the fly's method of carrying disease germs, a study of the **foot** and the mouth-parts or **proboscis** of the fly is most important. All parts of the fly's body, especially the feet (Fig. 58), are covered with stiff hairs well adapted for catching up filth particles containing disease germs. The last joint of each leg of the fly carries, first, a pair of claws fitted for holding on to rough surfaces, and, second, a pair of pads between the claws. The pads have short, knobbed and sticky hairs, with which the fly is enabled to walk on smooth surfaces like a window pane, or upon the ceiling. No doubt these acrobatic feats have all seemed wonderful to you. Would you not suppose that these sticky hairs could also take up dust and dirt containing germs of typhoid or diphtheria? The proboscis or sucking tube of the fly (Fig. 59), is likewise, on account of the presence of numerous hairs and bristles, a good collector of filth and disease germs.

How the House Fly Scatters Disease Germs.—Thus we see that we should look upon this otherwise pretty creature with fear and disgust. It is really the poisoner of millions of men, women and children. The house fly has fitly earned its new

name of "typhoid fly." It revels in filth. It visits the back yard of a typhoid patient, where careless people have placed the patient's body wastes. It covers the bristles and sticky hairs of its feet with filth and germs, and then flies into the kitchen or dining room and wipes its feet on bread and meat and jelly. "How awful!" you say. Then, beware of the fly! If, perchance, the typhoid-laden fly drops into a can of milk at a dairy, the germs multiply therein and may infect dozens of consumers of the milk. The fly may carry germs from the body wastes of one baby sick with summer complaint to the milk bottle with which another baby is fed, causing another case of sickness and perhaps death. If a consumptive spits upon the sidewalk it is easily possible for flies to carry the germs from the sputum or spittle to the candy eaten by a boy or girl living next door. The fly frequently carries filth several hundred feet from where he picks it up. Fig. 60 shows a plate of gelatine over which a fly had been allowed to walk. At first no tracks could be seen, for the germs that were left by the fly's feet were too small to be seen. But in twenty-four hours each germ had multiplied into a colony of thousands of germs. These colonies of germs can be seen in the picture. There is no longer any doubt that the fly is guilty of the crimes charged against these insects.

Fig. 59.—The proboscis or "tongue' of the fly.

Life History of the Fly.—The fly lays its eggs, as a rule, in the filth of horses or of man, the female fly laying about a hundred eggs at each brood. The egg hatches in less than a day into a legless, wormlike larva or maggot. Each larva feeds upon the filth until full grown, when its outer shell turns hard and

brown. The insect is then said to be in the pupa, or resting stage. While in the shell a wonderful change takes place, for soon the shell breaks open at one end and out slips the mature or adult fly. It takes about ten days in average weather to pass through the egg, larval and pupal to the adult stage.

Fig. 60.—This shows tracks left by a fly in crawling over a flat dish of gelatine. Each spot is a colony containing millions of germs.

How to Reduce the Number of Flies.—Flies are plentiful wherever filth or excrement is plentiful. If we remove the barnyard manure once a week we remove with it all of the young flies in the larval or egg stage. A good plan is to have a box or bin (Fig. 61), in which to keep the rakings from the stable and barnyard. The bin should be fly-proof and its contents should be hauled off once in ten days or oftener. It is much easier to prevent the hatching of flies than to catch them in the adult or winged stage. Fly traps are often useful for catching the adult flies. There are several good patterns on the market.

Observation Work.—Secure a number of fly traps and place them in good situations. Use different bait (moist bread, molasses, sugar-water, meat, etc.) in the different traps so as to find out the most attractive bait. It would also be interesting to capture a fly and study the parts (eyes, wings, proboscis. feet, feelers, balancers, etc.)

with a magnifying glass. Disinfect the fly by rolling it around in formaldehyde or hydrogen peroxide, and wash the hands in soap and water after handling the fly.

If flies get into the house in spite of all we can do to prevent it, they should be killed. Liquid poisons in sweetened water are sometimes used, but they are not to be recommended for the reason that the poisoned flies are likely to fall into the food and thus do as much damage as living ones. Sticky fly paper is the best means of killing the flies. The flail pictured in Fig. 62 can be used to kill flies as well as mosquitoes that gather on the inside of our screen doors and windows. If we darken a room, with the exception of one window, the flies will gather at this window, where they may be kllled.

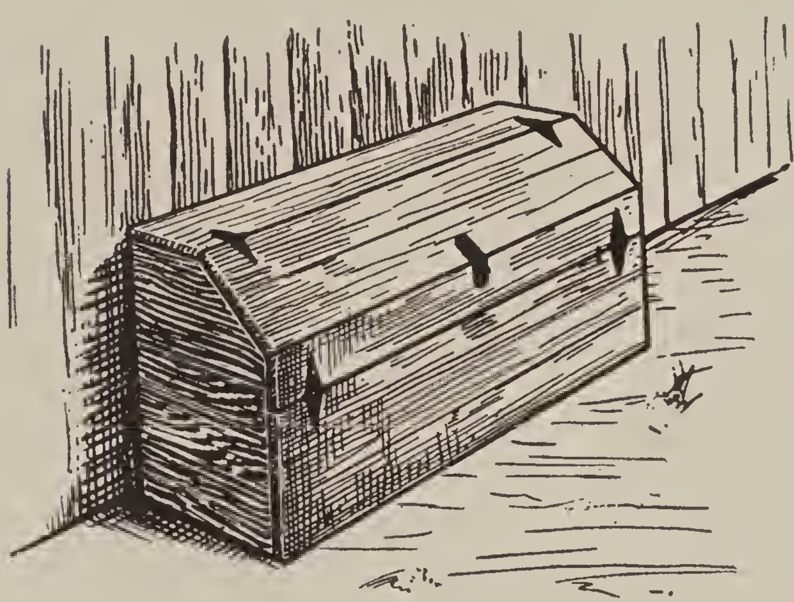

Fig. 61.—A fly proof manure-bin with lid.

Avoiding Disease.—To prevent the carrying of germs to our food we should first try to keep down the number of flies by removing their breeding places, and, secondly, screen our houses so as to keep the flies out of our kitchens and dining rooms. If you doubt the need of screens, take some lime and throw it onto the flies out near the stable or closet. Within an hour you will probably find flies with lime on their backs on your dining-room table. The best screens that can be obtained at reasonable cost are those made of galvanized wire.

To keep out mosquitoes as well as flies the wire gauze should have no less than 14 meshes to the inch and 16 would be better.

But after all the previous precautions advised we still have not done the most important thing to prevent the spreading of the diseases mentioned. **If we would not ex-expose germ-laden filth to the fly, there would be no germs for the fly to carry.** The most important thing to do to prevent the scattering of typhoid and other diseases is to disinfect the body wastes of the sick, as described in Chapter V. Typhoid fever is a filth disease. Flies can only scatter the germs, when the germs are placed where the flies can get to them.

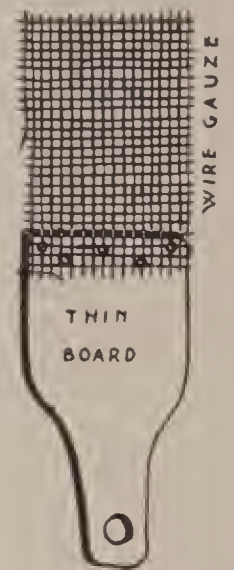

Fig. 62. — Fly killer.

The Tse-tse Fly.—In East Africa there is a disease known as the sleeping sickness. This is transmitted by the tse-tse fly, an insect about the size of our house fly, but different in having mouth parts fitted for piercing the skin and sucking blood. The germs live in the blood of the patient and are sucked up by the fly and then injected into the blood of the next person that happens to be bitten.

Observation Work.—In the fall of the year horses are much annoyed by big black blood-sucking flies. Capture one, if possible, and bring it to school as an example of a blood-sucking insect. Squash bugs (found on squash, pumpkins, etc.) might also be studied to get an idea of the sucking mouth parts of an insect. In this case, however, it is plant juices and not blood that is sucked.

MOSQUITOES.

Mosquitoes cause hundreds of deaths in Texas, such deaths being due to malarial fever, or what is more commonly known as "chills and fever," "malaria," or simply "chills." In all instances it is the mosquito which takes the germ of malarial

fever from a person sick with chills and fever and inoculates these germs into the blood of a healthy person through its bite, thus producing malaria. The germ of malarial fever is known as the malarial parasite.

Dengue fever makes its appearance in this State from time to time; and when cases do come in from Mexico and elsewhere, mosquitoes are here to spread the disease. Yellow fever threatens to slip in from South America every summer, but this will probably be prevented by the watchfulness of our quarantine officers. Yellow fever is not likely to become epidemic in Texas again in the present advanced state of scientific knowledge. The study of the mosquito is important mainly from the standpoint of preventing malaria and dengue fevers.

Fig. 63.—Yellow fever mosquito (Stegomyia).

Fig. 64.—Ordinary Mosquito (dengue).

Description of a Mosquito.—The mosquito is an insect with a single pair of wings and a pair of balancers. For our present purpose the most interesting part of the animal is the proboscis. This is not a simple affair, but a whole set of instruments in itself. There are six sharp pointed pieces in the proboscis for piercing the skin and making the blood flow. Then there is a tube, with which to suck up the blood, and this tube also acts as a duct through which the mosquito injects her saliva into the human skin.

How the Mosquito Scatters Disease Germs.—The germs of malaria are sucked up through the proboscis of the mosquito and into its stomach. Here the germs cause knots or cysts in the stomach wall and multiply in countless numbers. In fourteen days the germs are mature, and break out of the mosquito's stomach wall and enter the salivary glands of the mosquito. If then the mosquito bites a person, the germs pass into the blood with the saliva which the mosquito injects into the wound it makes.

Fib. 65.—Malaria mosquito.

Kinds of Mosquitoes.—Yellow fever, malaria and dengue are each carried by a particular kind of mosquito. The accompanying pictures show the three kinds, all of which occur in Texas.

Observation Work.—Secure a number of mosquitoes and try to identify them. This is not easy, even after looking at the pictures. The yellow fever mosquito (Stegomyia) has white markings in the shape of a lyre on the thorax and has striped legs. The malarial mosquito (Anopheles), when at rest, stands at an angle from the wall (Fig. 66), and has spotted wings; the common (or Culex) mosquito (Fig. 66) holds its body parallel to the surface on which it rests.

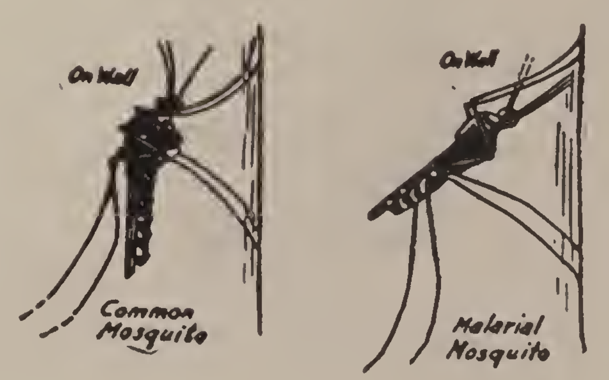

Fig. 66.—Showing how the malaria mosquito stands out from the wall.

Breeding Places of the Mosquito.—To destroy these insect enemies of ours we must learn their breeding places, and the habits of the young stages. We can keep the adult insects out of our houses, but we cannot kill them after they have grown wings and flown away. We may, however, easily keep down their numbers by filling up or draining their breeding places, and so getting rid of their young.

Everybody knows that the wiggler of our **ponds and puddles** is the young stage of the mosquito. but not everybody realizes what large numbers of mosquitoes may grow up in a very small amount of water. A **tin can** may catch enough rain water to raise a thousand mosquitoes in a summer. The **rain-barrel** or the **overground cistern** is often a source of a continuous stream of mosquitoes throughout the season. **Roof gutters** may become clogged and hold water after every rain. **Water troughs,** hoof prints of cattle in wet ground, urns in cemeteries, and even a neglected vase inside the house, may harbor mosquito wigglers.

Fig. 67.—Rain-barrel with lid.

The remedy for all this, and the easiest way to get rid of mosquitoes is to destroy their breeding places. City and county authorities should see to it that useless accumulations of stagnant water are drained. Necessary ponds and tanks should be stocked with fish which eat the wigglers. Tin cans should have holes punched into them and should be carried off, and other such breeding places of the mosquito should be removed. The rain-barrel and cistern should be made absolutely mosquito-proof with screen covers (Fig. 67) and strips tacked over cracks.

By referring to Fig. 25 you will see a cistern with the top open and exposed to mosquitoes. This cistern could be made more sanitary by covering it with boards, or, better yet, boards and cloth.

Life History of the Mosquito.—Before laying a batch of eggs the mosquito must gorge herself with food, such as the blood of animals or man. She then deposits the eggs on the surface of the water, where they swell up and float. The eggs of the dengue mosquito, or Culex, are in a raft-like mass of 200 to 400 (Fig. 68); those of other mosquitoes are scattered singly on the surface (Fig. 69) of the water. The eggs hatch in half a day, and out come wigglers, or larvae. These feed on tiny particles of organic material. It is interesting to wtach the brush-like mouth parts as they rake in the food. The Anopheles or malarial mosquito larvae lie flat upon the surface of the water (Fig. 69); larvae of other kinds feed at various levels and float with the head downward or submerged. When the larva becomes full grown it stops eating and becomes a pupa (Fig. 68) on the inside of which the adult insect develops. When the adult is ready to emerge, the pupa splits open at the back, and slowly the mosquito comes forth, pulling out its legs, feelers and wings, and using the pupal

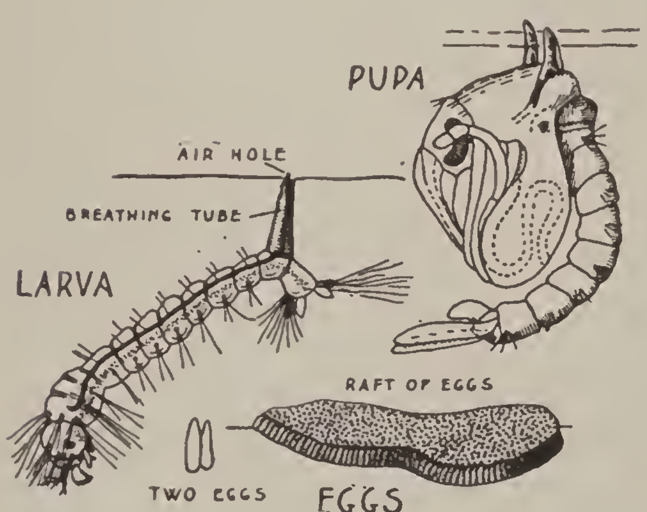

Fig. 68.—Showing eggs, larva and papa, or the different stages in the development of the ordinary or dengue mosquito.


Fig. 69.—Eggs and larva of the malaria mosquito.

skin as a raft until the wings are quite dry. After this it flies away to start another generation of mosquitoes.

How could one witness this magic transformation from worm to winged insect without thinking of the butterfly and the beautiful Greek story of Psyche, typifying the soul.

Observation Work.—Every school should organize an anti-mosquito brigade. Let the pupils look up and report all of the breeding places of mosquitoes in the school ward or school district.

Observation Work.—It is easy to rear mosquitoes in the school room. You may go down to the pond and find eggs, larvae and pupae and bring them to school in a glass jar. It is best to use the water in which they are found. Study all of the stages. See if the larvae change their skins. Watch the adults emerge. You may also set out a jar of rain water where mosquitoes abound and you will probably find eggs on the surface of the water in the morning. Drop a single cooked bean or bread crumb into the rain water for the larvae. If you want to keep some adult mosquitoes in a cage, capture a dozen or so, place them in a cage and feed them a slice of banana. Let the mosquitoes also have a tumbler of rain water in which to lay their eggs.

Destroying Mosquitoes.—Besides removing the water in which the larvae and pupae live, there is another way of killing them. This method depends upon the way the larvae and pupae breathe. In Fig. 68 both are shown at the surface of the water, with the breathing tubes protruding in the air. If, now, we pour oil on the surface of the water, the oil will spread over the surface in a thin film which the wiggler cannot penetrate. The wiggler, therefore, dies for want of air.

Experiment.—Place a few wigglers into each of two tumblers of water. To one tumbler add one drop of kerosene oil. Keep the other tumbler entirely free from oil. Note the result.

Adult mosquitoes that succeed in getting into our houses can be killed with the flail shown in Fig. 62 on the inside of our screens, where they gather about dusk.

Screens.—Some of the worst yellow fever and malarial districts of the world (Havana, Panama,) have been made habitable to man by the fight on the mosquito, by draining pools of water, and by the use of screens. Screens are necessary in all parts of Texas, both against flies and against mosquitoes. The river bottoms of Texas can be made quite safe for white people by the use of screens on doors and windows of dwellings. If a person has malaria, he should be carefully screened off from the other members of the family, and every precaution taken to prevent access of mosquitoes, the carriers of the disease.

FLEAS AND OTHER DISEASE CARRIERS.

Fleas.—Fleas are insects that have lost their wings and developed their hind legs for hopping. They live on all kinds of warm-blooded animals. The kinds of fleas that live on rats and ground squirrels are the ones most dangerous to man, because these animals may become infected with **plague,** the germs of which are carried from the living or dead rat to man. To fight plague, therefore, we must make war on the rat and the ground squirrel, as has been done in California in recent years. We have not had plague in Texas, but will be in danger of infection from ships coming from Asia through the Panama canal.

Fig. 70.—The flea carries plague.

Lice.—Body lice transfer typhus or jail fever from the sick to the well. This disease occurs in Mexico. Proper sanitary measures are almost sure to prevent its introduction into Texas.

Ticks.—Ticks are not strictly insects, but are much like

them. How many legs has a tick? A spider? An insect? Ticks have been proved to carry "tick fever" from cattle to cattle. The disease is deadly to imported cattle unless they are made immune by a special kind of vaccination, such as you studied in chapter IV. Cattle shipped out of Texas have to be "dipped" to kill the ticks.

Another kind of tick is responsible for carrying Rocky Mountain spotted fever to people. This disease originated in the Bitter Root Valley of Montana, where it causes about a dozen deaths annually. It occurs in other States now.

Summary.

1. Insects do not originate disease germs, but carry them from the sick to the well.

2. The house fly plays an important part in the transmission of typhoid fever and other intestinal diseases, carrying the germs with filth to the food of man; mosquitoes transport germs of malaria, dengue, yellow fever or other diseases in blood sucked from the patient; fleas, lice and ticks are also known to be carriers of disease.

3. Flies and mosquitoes are most easily got rid of by destroying their breeding places: barnyard filth for flies and stagnant water for mosquitoes. Rakings from the barnyard should be stored in a bin provided with a lid. Necessary standing water should be oiled and barrels and cisterns thoroughly screened.

4. All dwellings should be provided with fine wire gauze screens especially to keep out the typhoid fly and the malaria mosquito. Food at stores and restaurants should also be protected from flies.

Questions.

1. Name the insects that scatter disease and tell what disease each kind scatters. 2. How is the house fly adapted to gathering germs? 3. What is another name for this insect? 4. How can we best kill the adult fly? 5. Describe the development of the fly. 6. How can we prevent flies from multiplying? 7. How often should the barnyard bin be emptied, and why? 8. Describe the development of the mosquito. 9. How can we prevent mosquitoes from multiplying? 10. How do wigglers breathe? 11. How can we kill them? 12. How can you tell a larva of a malarial mosquito from other kinds? 13. How can you tell the adults apart? 14. Point out the eggs, larva and adult of the malarial mosquito in the pictures; also the adult in resting position. 15. How can we kill the adult mosquito? 16. Why is it more necessary to screen a patient sick with malaria than one sick with typhoid fever? 17. State three reasons why we should screen our houses. 18. How is plague spread? Typhus fever? Tick fever of cattle? 19. What would we have to do if plague should break out in Texas? 20. Which of the diseases mentioned above is it now most important for us to study about in Texas?

CHAPTER XV.

Keeping Germs Out of Our Drinking Water.

What are the things about drinking water that make it unsafe? This question is easy to answer; it is not the mineral matter, nor the decaying matter which a water may contain, but it is the germs of disease that harm us. Of course, there are poisonous waters that are not useful as drinking water, such as the strong gypsum waters found in certain parts of Texas; and there are some stagnant pools that are so full of filth that they would not serve as drinking water; but, on the whole, the only dangers that lurk in drinking waters are in the form of disease germs, and in this country, typhoid germs are the most to be feared.

Fig. 71.—Boy drinking from artesian well.

Water May Be Clear and Palatable and Yet Be Impure.—Disease germs are not visible except when placed under a microscope or viewed in large numbers, and it is impossible to tell by looking at a water or tasting it whether it is free from dangerous germs or not. There are many wells and springs which furnish water of a pleasant taste; such water may seem to be perfectly clear; and yet this water may contain hundreds of typhoid germs in each drop. It is important to realize how impossible it is to judge a specimen of water by its

appearance and taste. A much better way to form an opinion as to the purity of water is to examine into the source of the water.

Kinds of Water Used in Texas.—In general there are five kinds of drinking water used in Texas, as follows: rainwater, shallow well water, spring water, river water, and deep well water.

Fig. 72.—Showing how cistern water is made impure by birds, which carry filth from the ground to the roof.

Rainwater is perfectly pure when it falls, but when it falls on a roof that has been soiled by English sparrows and pigeons, it may become poisonous from the disease germs it contains. Underground cisterns subject to overflow or seepage may contain germs of typhoid fever. Water should be gathered in a cistern only from the sunny side of the roof, as sunlight is a good killer of germs. The gutters should be cleaned as often as necessary. Only water from winter rains should be allowed to flow into the cistern. Cisterns are of great importance as the breeding place for mosquitoes, as you have learned in Chapter IX.

The shallow well is the source of most of the drinking water used in many parts of Texas. This kind of well is usually less than a hundred feet deep, and includes practically all wells

except the deep or artesian wells. The shallow well is one of the most dangerous sources of water, but it can be made reasonably safe in most instances. In nine cases out of ten, the fault lies not in the lay of the land, but in the way the well is cased in, the method of drawing the water, or other things which can be corrected. When we take into account the fact that usually the water in a shallow well has filtered or seeped through at least twenty feet of closely packed earth, we must conclude that most of the germs would be filtered out. It is certainly true, however, that if a well is located close to a cesspool, especially on the down-hill side, and if this cesspool is filled with unclean material month after month, sooner or later, some disease germs are going to pass entirely through the soil and into the well. It is rare, however, that a well is located in such a foolish position. We may, therefore, conclude that the germs which filter or seep into a well from the bottom with the water are not so important as the germs that spill in over the top of the well or those that trickle in through leaks in the side of the well. Not only should the well be cased in, but the platform or cover of the well should be watertight in order to prevent the well from being soiled with material dropping off the shoes of the persons drawing water.

Wells Should Be Properly Cased in.—Fig. 73a. shows a typical faulty shallow well. Point out four errors in the construction of this well. Fig. 73b. shows the same well with the faults corrected. Ordinarily it costs about fifty cents a foot to dig a well in Texas. The model well shown in the picture is cased from bottom to top with concrete rings, which are fitted together with cement so as to make a perfectly watertight joint. These rings are usually molded to fit a standard well, three feet in diameter, and it takes about thirty dollars

to pay for the casing in of a well thirty feet deep. The concrete rings are superior to brick or stone because they have fewer joints. The model well shows the concrete rings built up two feet or so above the surface of the ground, and when this is done, the mound around the surface of the well is unnecessary. It is a good rule, however, to hill up the soil

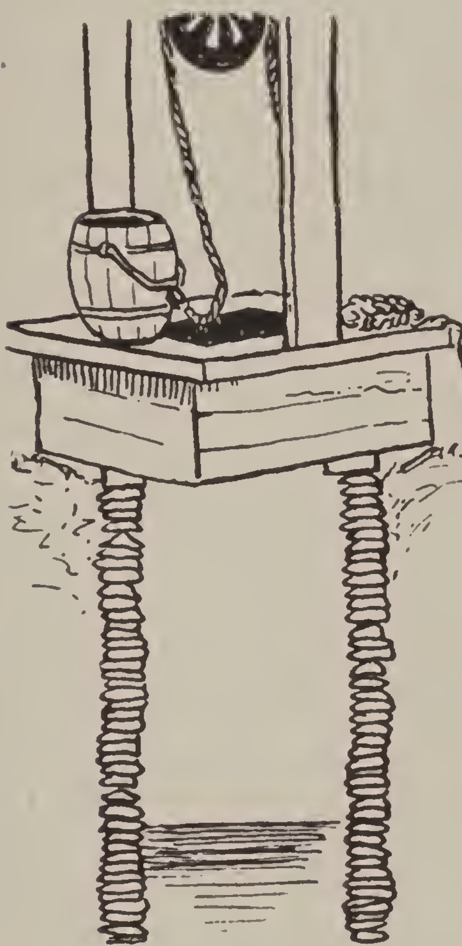

Fig. 73a.—An improperly constructed well.

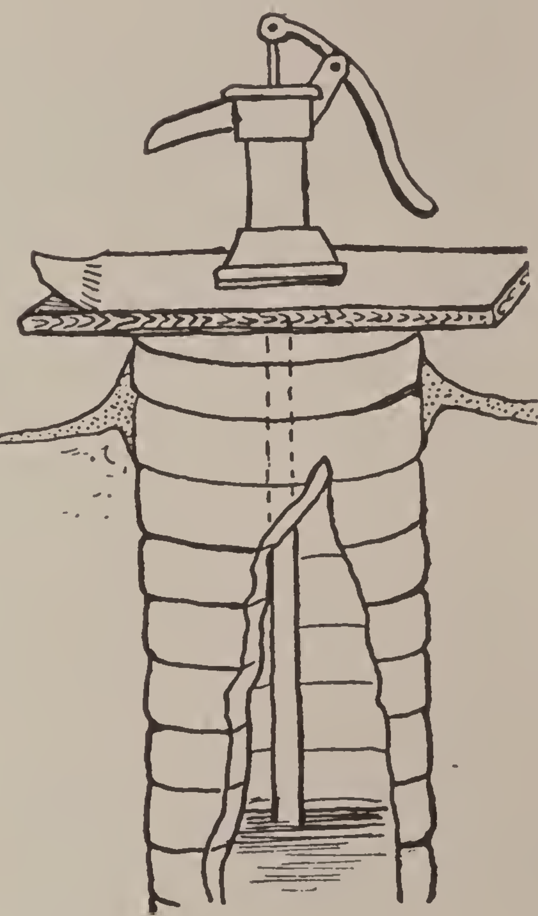

Fig. 73b.—A good well. Less chance for entrance of germs.

around the top of every well to prevent surface water from running in. To make a still better well, a two-inch cap of concrete can be placed over the mound for a distance of three feet from the well in every direction. This is pictured also.

Rope and Bucket Are Not so Sanitary as a Pump.—The model well is fitted with a pump. This delivers the water into the bucket in a pure state. If the water is drawn with a rope and bucket, the drippings from the hands are almost sure to fall into the bucket. From what you have learned about typhoid fever you can readily see how easy it would be for a person nursing a case of typhoid fever to transfer the germs from her hands to the water.

Spring water is not a safe water supply if we take it year in and year out. It gets its supply of water from the surface also. The spring is not usually dangerous, however, if it be protected so that no water can get in except through the fountain head of the spring. A spring should have a concrete curb around it to keep the nearby surface from draining into the spring. If a spring is on the down hill side of a house, and most of them are down hill, and if a house is close by, it is dangerous, especially if it has not a watertight curb or rim around it.

River water is the main source for the water of most of our cities, and is usually so dangerous that it has to be treated in some way before it is safe to use at all. It is easy to see that many filthy things get into a river, and were it not for the purifying action of the sunlight and air, and the filtering of the sand, river water would be entirely unusable. River water is especially dangerous when a city or town is upstream; in other words, river water is especially dangerous just below a city or town. Some cities keep an account of all cases of typhoid that occur along the banks of the river for miles and miles above their intake pipe.

At this time there is some danger from the water supply of several of the cities of Texas, and a good plan would be, in case of an epidemic of typhoid in any city or town, to

ask your local health officer about the water supply. In case of doubt, boil the water. Do not forget the fly and the milk supply, however.

Deep well water is absolutely safe, provided no surface water can leak in from the top. If the casing is watertight no leakage can occur. The casing is usually made of iron pipe.

Fig. 74.—Boys out hunting should not drink from little streams.

Importance of Water Supply of Summer Camps.—The pleasant climate of Texas, and the excellent facilities for enjoying camp life entice many campers out into the groves and prairies each year. It is not at all uncommon for these campers to contract typhoid fever while out on their vacation, and as the fever requires two weeks to develop, these spells of fever usually come on after the campers have returned to the town or city. We should learn from this the necessity for being careful about selecting drinking water even when out for a few days' trip. The picture shows a lad drinking from a little brook. These little streams are often poisoned by the germs which have washed into them from the premises of farmers up the stream.

Contamination May Occur After Water Is Drawn.—Even if we have a good water supply, bacteria may get into the water after it is drawn unless we take certain precautions in the handling of it. The public drinking cup is a great danger. You have learned in Chapter III and others how the secre-

tions from our bodies are likely to contain the bacteria which cause disease. Each time that we put a drinking cup to our lips, some of the saliva which has dried on our lips is removed

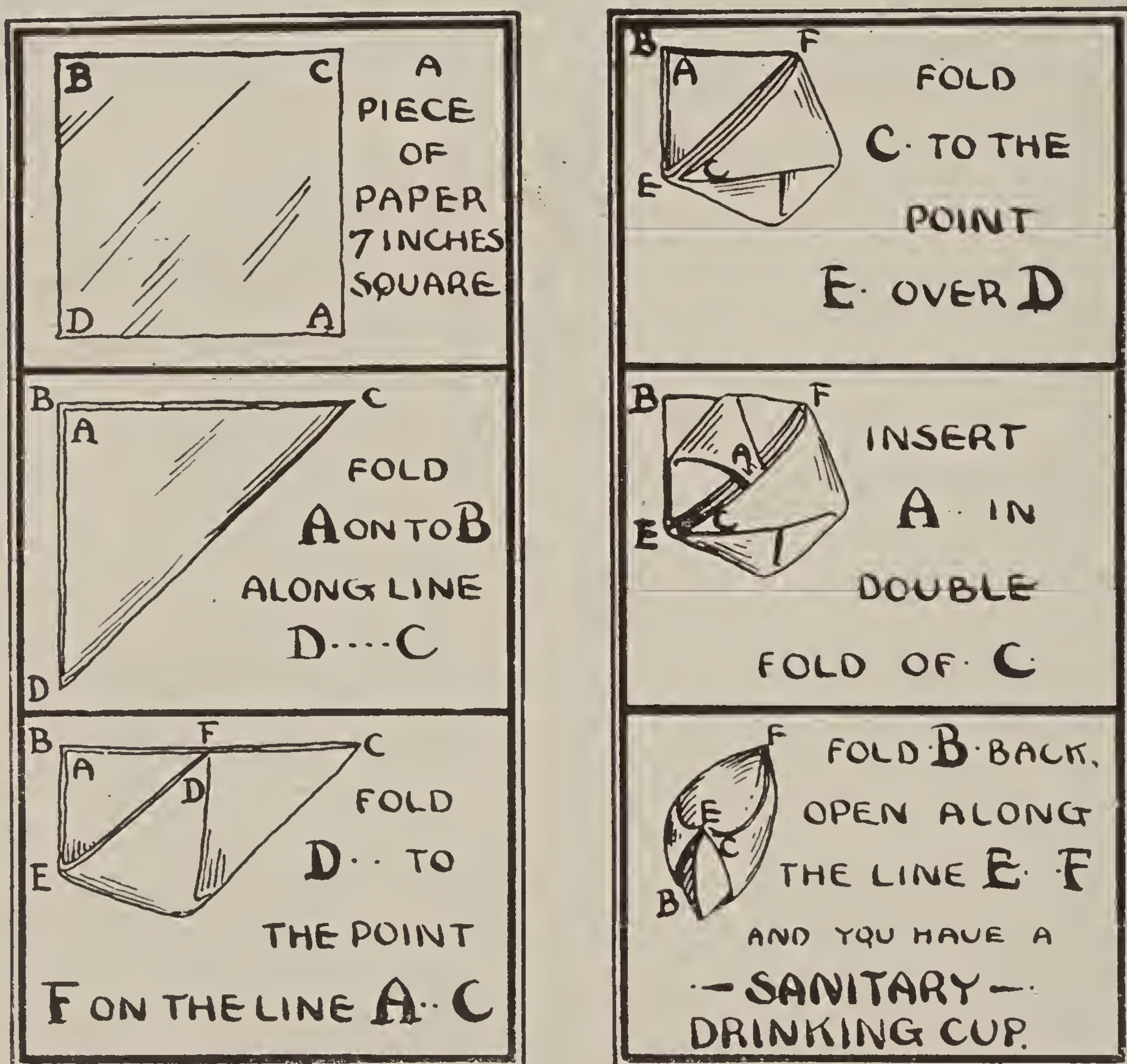

Fig. 75.—This picture shows how to make a sanitary drinking cup.

by the cup. Needless to say, any germs that are in our system are likely to be spread in this way. It has been proven that the germs of diphtheria, tuberculosis, typhoid fever and other dangerous diseases have been distributed by the public drinking cup. (See Sanitary Code, p. 337, Rule 61.)

How to make a sanitary drinking cup out of a square sheet

of paper is shown in Fig. 75. In making these cups be sure to start out with a clean sheet of paper, and do not put the fingers inside to pull it open. The sanitary cup should be made by the person who is going to use it, and should be used only once.

The Sanitary Drinking Fountain.—In public places the sanitary fountain is coming to be used. One of these is shown in Fig. 76. They should be made with the valve out of reach of the fountain, so that they must be turned on before one begins to drink, and continue to run till after he stops drinking. If they are made with the valve close to the fountain, some children place their mouths on the outlet before turning the water on. This defeats the object of the sanitary fountain.

Fig. 76.—Sanitary fountain in one of the Houston schools.

Typhoid fever is without doubt the disease we should think of when we study the water supply. We should not, however, forget that the fly probably causes more typhoid fever in Texas than the drinking water. You have learned in Chapter V how to tell whether a given epidemic is due to drinking water. In towns, if the epidemic is due to water, it is likely that a great many persons will be affected at the same time, and all parts of town using a given water will be equally affected. If the epidemic comes up in spring time, and gets gradually worse as the summer wears on, and as the flies increase, it is not

likely to be due to the water. It is more likely to be due to the fly, especially if certain unsanitary parts of town are affected worse than others.

Cholera is spread by drinking water also, but that disease is not likely to attack us. It has been almost stamped out in the greater part of the civilized world. Hookworm disease may be spread by drinking water to some extent, and it is probably widespread in the older parts of the State, especially in the sandy regions. Amebic dysentery is spread by drinking water, but there is not a great deal of it in Texas. It is likely to be brought in at any time from Mexico, but is not an epidemic disease.

All Typhoid Germs Come From the Bodies of the Sick.— Probably the most important thing to remember in connection with the spread of disease by drinking water is the fact that the germs have to originate in the body of some one sick with typhoid or other disease. If the germs are not poured out on the ground, they cannot be washed into the well or river. We see at once that the best place to attack disease is in the sick room, and the best method of attacking it is to disinfect all body wastes so that the germs are done away with forever. You have learned how to disinfect in Chapter V, and will learn more about it in Chapter XVI, which is devoted entirely to disinfection. When we disinfect the body wastes we are "heading the germs off" from our drinking water.

Fig. 77.—"Heading the germs off" from our drinking water.

Important Points.

1. It is not the chemical or mineral contents of water, but the bacteria, which make it unsafe.

2. A water may be clear and palatable and yet dangerous.

3. Cistern water may be contaminated by bacteria carried to the roof by pigeons and sparrows, or it may be contaminated by surface water which overflows or leaks into the underground cistern; owing, however, to the mosquitoes which breed in cisterns, they are usually of more importance in the spread of malaria than of typhoid.

4. The shallow well is dangerous, but can be made a reasonably safe source of drinking water by observing the location of the well, by casing it in properly, by covering the well properly, and by having a pump to raise the water.

5. River water is risky and usually has to be treated by filtration when used as a public water supply; in time of an epidemic in towns and cities the water should be boiled till the cause of the epidemic has been found and removed.

6. The deep well, when properly cased in, supplies a perfectly pure water.

7. Bacteria are frequently introduced into drinking water after it leaves the well, as, for instance, by the public drinking cup.

8. Typhoid fever is the disease which drinking water spreads, although this disease is spread in other ways also.

Questions.

1. Why must we be careful in selecting drinking water? 2. Of all diseases spread in Texas by drinking water, which one causes the most deaths. 3. Do you understand this to mean that water is the only cause, or most important cause of the spread of this disease? 4. What are the dangers of the uncovered cistern? 5. What is the object of locating a well on the uphill side of a house? 6. What is the object of casing the well in, and how should it be cased in? 7. Why is a pump safer than a bucket and rope? 8. What is the object of having a watertight platform or cover for the well? 9. Why should the earth be hilled up around the well? 10. What disease can be spread by the public drinking cup? 11. What is the danger in placing one's mouth over the outlet of a sanitary fountain before the water begins to flow? 12. Fold a sanitary drinking cup. 13. Where do the disease germs come from that are in drinking water? 14. Where is the best place to kill these germs?

CHAPTER XVI.

Disinfection, or How to Kill Bacteria.

In this chapter we shall learn how to kill bacteria in various ways. They are very easy to kill if one knows how, but they are not all alike, and what will kill one variety of bacterium may not kill another. So the question is an important one to study. Remedies that kill germs are called **germicides, disinfectants,** or **antiseptics.**

Sunlight and Fresh Air Are the Best Disinfectants: They kill germs better than any other remedies, and they are also very helpful to human beings. So wherever we can get a supply of bright sunlight we shall not have many germs. There are some things, however, that we need to notice about the action of the sun on bacteria; for instance, the sun must shine didirectly on and against the body of the bacterium before it can kill it. If you take some tuberculosis germs and place them in a thin layer on a pane of glass, and then put this in the sunlight, the germs will be dead in a few hours. But if you take the germs and throw them on the ground, some of them will remain on the top of the ground and can be readily reached and killed by the sunlight, while others may sift down into the dirt so that the sun cannot shine upon them. These will not be killed until the sun has shone on them for many hours.

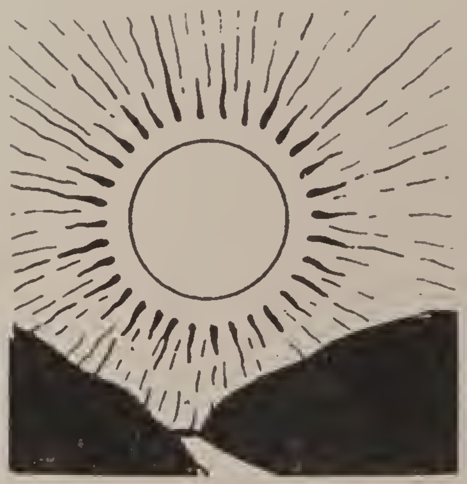

Fig. 78a. Sunlight is a good disinfectant.

Inside the house in dark corners the germs of tuberculosis can live for months.

Next to the sunshine, soap and water are the best disinfectants for everyday use. If we use plenty of water and plenty of good soap, our skins will be kept almost free of germs. If we keep the hands clean we shall escape those diseases spread by fingers, such as typhoid fever.

Fig. 78b. Soap and water: another good disinfectant.

Difficulties of Disinfection.—But there are times when we wish to destroy all germs in a certain place, and do it at once. In these cases we can use heat, or we can use certain powerful chemicals or drugs. You will see that we are now dealing with disinfectants powerful enough to kill any germ, or to kill even human beings, if they are not used properly. And we might as well learn here that germs are to a certain extent like human beings, because they are living things; and that whatever tends to kill the germ, might also tend to kill the human being. This will make clear to you the difficulty of killing germs when they are in our bodies. You see, we must try to find something that will kill the germ without injuring our bodies. We have found a few remedies of this kind, and one of them is quinine. Quinine is very poisonous to the malarial germ, and, when taken in the proper dose, will almost always kill all that are in the patient's blood. At the same time quinine is not injurious to the average man. But quinine is not very poisonous to germs other than the malarial germ.

Unfortunately, we have no chemical that will kill the tuber-

culosis germ in the human body without injuring the body itself. For this reason, all cures of consumption are frauds, and no man who is honest will claim to be able to give medicine that will rid the human system of the bacteria of tuberculosis.

Boiling Kills Germs.—But in case the bacteria which we wish to kill are not in the human body, our task is much easier. Ten minutes' boiling will kill any bacterium known. One minute's boiling will kill almost all bacteria. But there is a special trick by which certain bacteria can withstand boiling for several minutes. They have a way of forming a hard shell around themselves, and when they have done this they are safely shut up like a turtle in his shell. It is only certain kinds of bacteria that form these shells, and we call the bacterium with its shell around the outside a "spore." The tetanus or lockjaw germ, and the germ of charbon, which attacks cattle, are two germs which have the habit of forming spores. You will see that our worst diseases, such as tuberculosis and typhoid fever, are caused by germs that are very easy to kill, once we get at them. The meningitis germ is very easy to kill. One minute's boiling will kill the germs of most diseases.

Fig. 79a. Boiling water is an excellent disinfectant.

Chemical Disinfectants.—But it is not always convenient to boil things, and there are certain chemical disinfectants which will kill germs just as certainly as heat. Probably carbolic acid is the commonest one of these. A solution of carbolic acid, made by adding one tablespoonful of the acid to a quart of water, will kill any of the germs except the spores in five min-

utes. Now, this is a strong solution, and yet it takes five long minutes to kill the germs. Some people have the mistaken idea that a saucer of carbolic acid placed under the bed will disinfect the entire room.

There is a mistaken idea in the minds of some people who believe that by removing bad odors they can disinfect a room. Some even go so far as to believe it is sufficient to cover up these bad odors with other stronger ones. This is not only useless but is harmful, because it gives a sense of false security or safety. In the toilet rooms of many public buildings, hotels and the like, are to be found little metal cylinders which give off a peculiar odor. These are not of any service in destroying disease germs. It would be just as sensible for us to use perfume instead of bathing as it is to place these strong-smelling cylinders in our buildings. Another mistake made by some people is that of confusing disinfectants with insecticides. There are some remedies which are sure death to insects but harmless to germs; there are also some remedies which kill germs effectively but do not harm insects. The gasoline mixtures which do such good service as insecticides are usually ineffective as disinfectants.

The following table shows how the various disinfectants should be diluted for use, and tells which are most dependable. All things considered, the coal tar disinfectants are the most effective and the cheapest disinfectants. There are several of these preparations on the market, and the State Bacteriologist has prepared a list giving the exact strength of each disinfectant. This list will be furnished upon request to the State Board of Health at Austin:

In buying a disinfectant always take into consideration how much diluting is required. It is best to rely upon reports made by the Marine Hospital service at Washington or the State Board of Health at Austin, as to the strength of a given disinfectant. Of two disinfectants at the same price, buy the one of greater strength, which will require greater dilution and "go farther."

Table Showing How Long It Takes Certain Disinfectants of Given Strength to Destroy Germs.

Name of Disinfectant.	Name of Germ.	How to Make Solution.	Length of Time Needed to Destroy Germs Mentioned.
Boric Acid.	Typhoid.	Teaspoonful to teacup of water	Does not destroy all of the germs even in a week's time.
Boric Acid.	Pus Germs.	All that will dissolve in water	Has very little effect on germs
Carbolic Acid.	Typhoid.	Tablespoonful to quart of water.	Five minutes.
Carbolic Acid.	Pus Germs.	Tablespoonful to quart of water.	Five minutes.
Carbolic Acid.	Charbon Spores.	Two tablespoonfuls to pint of water.	Spores live four to forty-five minutes.
Corrosive Sublimate.	Typhoid.	Three grains to pint of water.	Five minutes.
Corrosive Sublimate.	Pus Germs.	Seven grains to pint of water.	Five minutes.
Corrosive Sublimate.	Charbon Spores.	Three grains to pint of water.	Twenty-six hours
Coal Tar Disinfectants.	Typhoid.	Teaspoonful to pint of water.	From one-half to five minutes.

Fumigation.—So far, the chemical disinfectants mentioned are useful only where we can place the thing to be disinfected into the solution. But when we come to disinfect an entire room, as, for instance, when we move into a rent house, we cannot do this, and so we have to use a gaseous disinfectant, such as formaldehyde. The formaldehyde method of disinfecting a room is very effective, is not difficult, and does not damage any of the furnishings usually found in a living room. The following directions are taken from the book of instructions of the Texas State Board of Health:

To fumigate an average sized room the only utensils needed are an old three-gallon scrub bucket made of zinc (not wood) and three bricks. Secure from the drug store 13 1-2 ounces of potassium permanganate and a quart of formaldehyde. Place

Fig. 79b. Fumigating a room in a rent house. This should always be done except in a house that is new, or one in which the family moving out were in perfect health. Books are shown in these pictures, but are not well disinfected by this method. They should be burned if infected by dangerous disease germs.

the bricks in the center of the room on the carpet or the floor and the bucket on the bricks. Close the room up tight and place strips of wet paper over all cracks and openings. Put the permanganate into the bucket and pour the formaldehyde over it. Leave the room at once, closing the door tightly, and do not open the room for at least six hours. It is a good plan to stretch all linen, quilts, etc., on a line so as to expose as much

surface as possible to the disinfectant gas. They should not be thrown in a heap. (See also Sanitary Code for Texas, page 337, Rules 55-60.)

Mixed Disinfectants Are Not Good.—Just here we might notice the effect of mixing disinfectants. If we take half the proper amount of carbolic acid to kill typhoid fever germs in five minutes, using one-half tablespoonful instead of a whole spoonful to the quart of water; and if we add to this half the proper amount of corrosive sublimate to kill typhoid germs in five minutes, using one and one-half instead of three grains to the pint of water, we will then have a solution which ought to kill typhoid germs in five minutes; for there is half enough carbolic acid to kill them, and there is half enough corrosive sublimate to kill them. But the two chemicals do not reinforce each other very much, and the mixture will not kill the germs in five minutes. This would teach us not to mix disinfectants. For this reason all the patented mixtures sold as antiseptic are not so good as solution of carbolic acid for disinfecting. For this reason also the small sulphur and formaldehyde candles, which are often sold are worthless.

Important Points.

1. The soap and water and sunshine will have a great influence on your daily life. Keeping your hands clean, and cleansing them especially before eating, will be a health-saving habit for you to form.

2. The knowledge of the chemical disinfectants will be useful to you principally in teaching you the worthlessness of most so-called antiseptic treatments. You have learned that it takes strong chemicals and a considerable length of time to kill bacteria.

3. Every family should fumigate or disinfect each house before moving into it, unless they know something of the history of the house and its occupants for the twelve months preceding their occupancy.

Questions.

1. Name ways of killing germs. 2. Is it easy to kill germs in the human body? 3. How long can disease germs live in boiling water? 4. What are spores? 5. Name one disease germ that forms spores. 6. What two things are of importance in killing germs with carbolic acid in water? 7. When should we disinfect a room by fumigation?

CHAPTER XVII.

The Most Valuable Thing in the World.

What is the most valuable thing on earth? Some of you may answer friendship, gold, radium, platinum, diamonds. There is one thing, however, which we must have before we can use or enjoy any of these things, and that is life itself; the most valuable thing in the world then is human life.

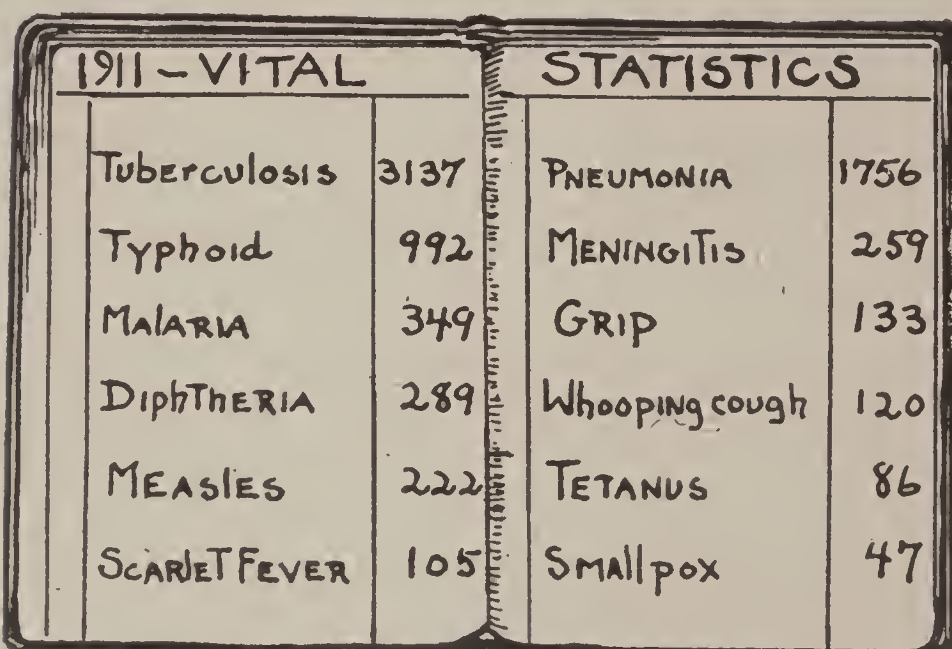

Fig. 80.—These figures show the deaths from certain preventable diseases in Texas during 1911.

Bookkeeping—Every merchant keeps a set of books showing the money he takes in and pays out. He does this because the money is worth a great deal. Just so, every civilized government keeps a set of books dealing with lives, as well as dollars. This set of books shows the number of lives received each day, or, in other words, the number of little babies born. It shows also the number of lives paid out each day, and what they were paid out for; that is, the number of deaths and what the deaths were caused by. If a merchant finds that he is paying out a great deal of money for coal, he will try to find some way to stop the ex-

pense, beause money is valuable to him. Just so, if the government finds it is paying out a great many lives each day on account of typhoid fever, for example, the government will try to stop the disease, because the lives are valuable. Now, this set of books kept by the government we call "**Vital Statistics.**"

Usefulness of Vital Statistics.—There is no use in keeping this list of deaths unless it is studied with a view of saving life. And, on the other hand, it is hard to try to save people from sickness unless you have a list showing which diseases are killing the most people. Suppose the pupils in your school wished to try to help prevent disease, and started in by studying the plague. There hasn't been a case of plague in Texas, however, for many years; probably there has never been any here. You could not help Texas people much in that direction, could you? But by observing the records of vital statistics you will see that typhoid fever kills a hundred people or more in Texas each month; you might then do some good by trying to prevent typhoid fever. After you had been at work a year or two and found that typhoid was killing only fifty people in a month, you would feel that you were going at the business of life-saving in the right way, wouldn't you? It would be foolish to try to prevent disease without keeping a complete record, so as to see where prevention was needed, and to see whether prevention was a success.

Other Purposes of Vital Statistics.—It has been found that vital statistics can be made to serve other good purposes besides protecting the public health. The official records of births and deaths, for instance, are useful in settling disputes as to age and inheritance. Most States that have a system of vital statistics require a death certificate to be signed and filed with the proper officer before allowing a burial to take

place. Murderers and poisoners find it impossible to get a death certificate signed, because there is no physician who knows the cause of death, and hence the body of the victim of the crime cannot be buried legally. When the murderer tries to get a physician to sign the certificate, or tries secretly to bury the body of the victim, he is frequently detected and brought to justice.

Undertaker Fills Out Death Report, But Physician Must Specify Cause of Death.—It has been found most practical to require the undertaker to fill out and prepare the death certificate, for oftentimes the physician rarely goes back to the house after the patient's death. The undertaker always has dealings with the family just after the death occurs, and hence he is best situated to get the information required on the death certificate. The physician, however, is the only person qualified to pass on the question of the cause of death, and so the law in Texas requires him to sign the death certificate, giving the cause of death. The report of the death is filed with the city physician in case the death occurs in a town or city; if it occurs in the country, or outside of an incorporated town, the report of the death is sent by the undertaker to the county clerk. The officer who first receives the death report sends it to the State Registrar of Vital Statistics at Austin, and once each month the State Registrar publishes a statement of the causes of all deaths reported during the month. (Study in this connection the Sanitary Code for Texas, page 337, Rules 34-50.)

Texas Statistics Are Valuable But Incomplete.—Up to this time a little more than half of the United States preserves complete and accurate vital statistics. In the thinly settled parts of the country it is hard to get the deaths and births reported.

Texas has not succeeded yet in getting complete reports of all its deaths, but it has been making rapid improvements in this regard, and no doubt will have a complete set of returns before a great while. We cannot compare our Texas vital statistics with those of other parts of the United States without making certain changes to make up for the incompleteness of our reports. But we can make these changes, and in that way, with a fair degree of accuracy, compare our health conditions with the conditions in other States.

Comparison of Texas With Other States.—We will begin by assuming that Texas has about the same annual death rate as Indiana, or 13.5 per thousand. In order to make comparison easy, it is customary for all death rates to be calculated on a basis of so many per thousand inhabitants, or so many per hundred thousand inhabitants. When this is done it saves us the trouble of taking into account the number of inhabitants of each place. The following table shows the death rates of several States from several of the important diseases. The figures from the United States as a whole are given in order to give us an idea of the average death rate over the entire country. The rates from Massachusetts are given because this is an old and thickly settled State, and has an especially good set of health laws. The rate from Indiana is given because this State is largely agricultural, like Texas, and hence the conditions in the two States are more or less similar.

In the table the first column of figures refers to the annual death rate per thousand of population; all the other columns refer to the annual death rates per hundred thousand of population:

	All Causes.	Typhoid Fever.	Tuber-culosis.	Measles.	Scarlet Fever	Sm'll-pox.
United States...	15	23.5	139.7	12.3	11.6	0.4
Massachusetts ...	16.1	12.4	137.6	11.6	8.0	0.0
Indiana	13.5	34.	144.9	16.6	7.5	0.1
Texas	13.5	48.3	136.1	4.6	1.9	2.0
Paris, France....	16.7	7.0	.....	....	....	...

From this table we learn that Texas makes a favorable showing so far as the more contagious diseases are concerned, but makes a very poor showing in the case of typhoid fever. In proportion to her population Texas loses almost four times as many citizens from typhoid fever as Massachusetts, over twice as many as the United States as a whole, and over eight times as many as Paris, France.

Important Points.

1. A good system of vital statistics is necessary as the first step toward intelligently attempting to improve the public health.
2. Our Texas system is not perfect but is very valuable, and we should make every effort to improve it.
3. It can easily be seen that we have in Texas more than our share of typhoid fever.

Questions.

1. What are vital statistics? 2. Why do we keep accounts of births and deaths? 3. Have we valuable statistics of deaths in Texas? 4. Are they perfect? 5. Who should report deaths? 6 Whom should he report them to? 7. Compare the death rate from typhoid fever in Texas with that in Massachusetts. 8. Compare the death rate from measles in Texas with that in Massachusetts or Indiana.

CHAPTER XVIII.

The Body a House of Many Parts.

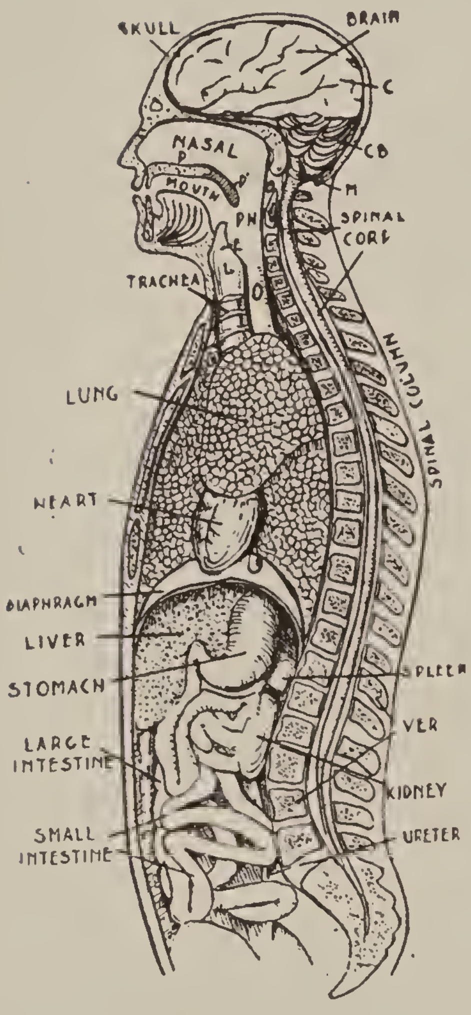

Fig. 80a.—Diagram of a section through the body to show the location of the principal organs

Up to this time you have learned of the microscopic bacteria which sometimes invade the body in countless swarms, and which tend to destroy our health by the poisons they give off into the blood. Truly wonderful it is how our bodies can defend themselves against their enemies, the germs of disease, as has been described in the preceding pages. We shall now learn many other wonderful things that the various organs of the human body have to do. We shall study the **physiology** of the organs, that is, their functions or duties, and how they perform these. To understand their functions we must first learn the structure of the organs; this study is called **Anatomy**. After you have learned the function and the structure of an organ or system of organs, you will be told how to keep the organs in a condition favorable for doing their duty properly. The last study is called **Hygiene**, or the "Science of Health."

Review and Observation Work.—Review Chapter I; draw an outline sketch of Fig. 80a, and in drawing name the organs men-

tioned in the chapter. If possible, secure a manikin or model of the human body, and, with the aid of this, study the organs.

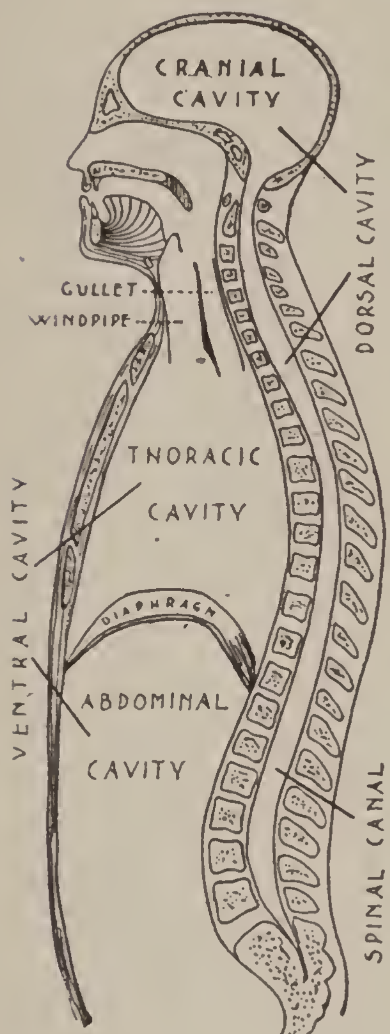

Fig. 80b. — Diagram showing the principal cavities of the body.

Organs.—From the frequent use of the word organ, and from your study of the figures as directed, you are led to conclude that an organ is **a particular part of the body**; and when you recall what you already know of the work of the organs, like the heart, you will come to the conclusion also that each organ has a **particular duty to perform**. Thus, for example, the heart is an organ that pumps blood. Mention some other organs and tell what you think their duties are. Now, define organ in your own words.

The chief organs of the body may be located by a study of Figs. 80a, 80b, 80c.

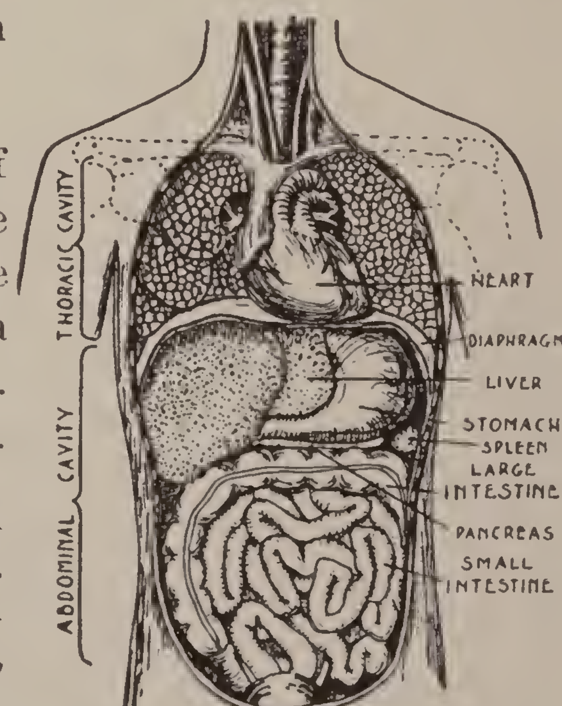

Fig. 80c.—Ventral view of the principal organs in the thoracic and the abdominal cavities.

The brain and the spinal cord are seen to occupy the **dorsal cavity,** so called because this cavity is located on the dorsal or "back" side of the body. The **ventral cavity** (the large cavity on the ventral or "front" side of the human body) is separated into the **thoracic** and the **abdominal cavi-**

ties by the diaphragm. Above this partition are the heart and the lungs that have to do with the pumping of blood and breathing respectively. Below the diaphragm are the organs that have to do with digestion and other functions.

Finer Structure of the Organs.—Each organ is in turn composed of parts called **tissues.** There are different kinds of tissues, and each kind has a particular work to do in the organ. Take, for example, a piece of beef. The soft, red part is **muscle tissue**; it is the main tissue that goes to make up organs called muscles. But muscle tissue is very tender, and would not hold together by itself. The tissue that binds muscle tissue together is tough and pliable, and is found in all muscles; it is called **connective tissue.** This may be seen as glistening white strands in beef or other lean meat. It also serves to bind muscles to bones and bones to each other. The sinews or "leaders" in the legs of deer were used by the Indians for bow-strings on account of their toughness, for they consist of connective tissue. In the muscle shown in Fig. 81, the part at A consists mainly of connective tissue; at B, mainly of muscle tissue; at C, of about an equal amount of each. Other white strands often seen in a piece of meat are nerves, which consist of **nerve tissue.** Thus a muscle is an organ consisting of muscle tissue, connective tissue, nerve tissue and other tissues not so easily seen.

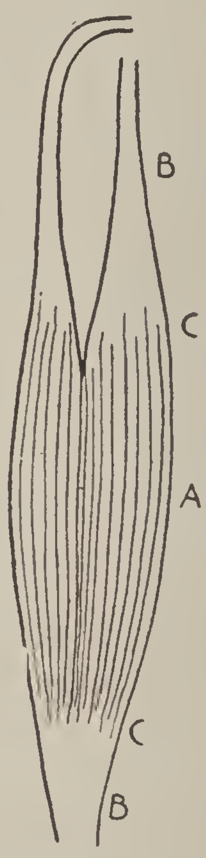

Fig. 81. A muscle.

Observation Work.—Secure a piece of "soup meat" or other tough meat from around a bone, and let several pupils each take a small piece and "dissect it." To do this lay the specimen on a board or an old newspaper and pick it to pieces with a knife or sharp

sticks. How many kinds of tissue can you find? Let all of the pupils see them. Describe the kinds of tissue that you can readily see.

Cells.—Our study does not end here, however. With the unaided eye we cannot find out anything more about the tissues; but with the aid of the microscope men have been able

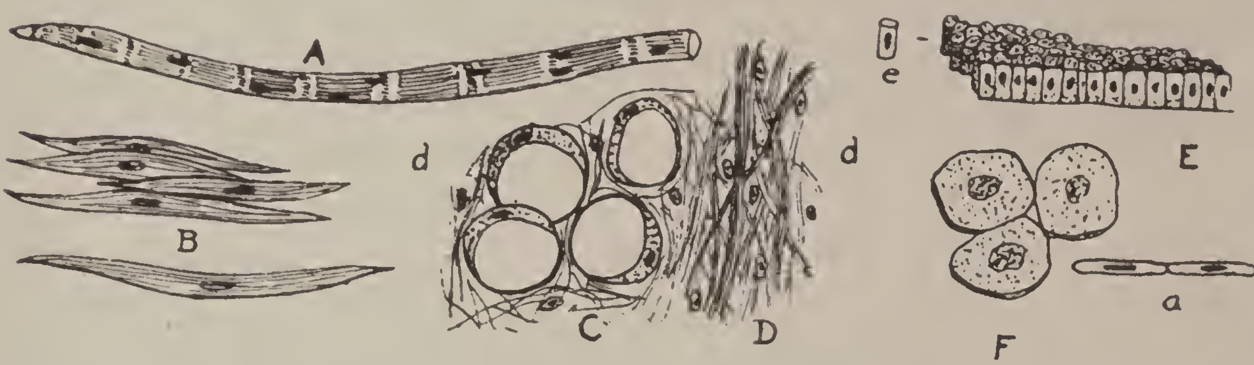

Fig. 82. Different kinds of cells: A and B, muscle cells; C, fat cells; D, connective tissue cells; E and F, epithelial cells; e, a single cell; a, end view of flat cells.

to discover that the tissues are themselves composed of very tiny parts called **cells.** A muscle-cell from the arm would look something like Fig. 82 A, under the microscope. Another kind of muscle cell is shown at B. Connective tissue cells are shown at D. Some of the cells are very long and are called **fibers**; some are of more nearly equal length and thickness like grains of rice or corn; some are large and full of fat and are called fat cells. Tissue that consists largely of fat cells is called **fatty tissue,** and is pictured at C.

Observation Work.—To get an idea of what a fiber looks like, take a sheet of good smooth writing paper. Tear off a corner and examine the torn edge, holding it between the eye and the light. The frazzled edge shows tiny fibers, comparable to the fibers of muscle and connective tissue.

Even these tiny cells, some of which are so small that hundreds could find room on the point of a pin, are in turn composed of definite parts. These parts are (1) the body of the cell, and within that (2) a denser portion, the **nucleus**, as shown in Fig. 83.

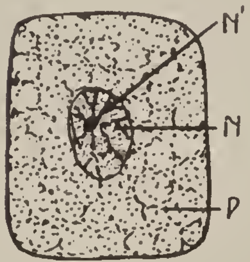

Fig. 83. A cell, showing nucleus, N.

Another kind of tissue is one called **epithelial tissue** (Fig. 82 e), and the use of this in the body is to cover surfaces or to form glands. You can easily imagine the shape of cells in this tissue. They would not be long like connective tissue or muscle fibers, but more like cubes or cylinders or discs (Fig. 82 e). It is sometimes called pavement tissue. This expression is good, as it compares the tissue to a pavement or a tiled floor. The individual bricks or blocks or tiles of the pavement would be compared to what in the epithelial tissue? Diagram E in Fig. 82 pictures some very flat epithelial cells scraped from the inner surface of the cheek as they appear under the microscope, much enlarged. At B is seen their appearance in end view, which serves to show how flat they are. The outer horny skin is an epithelial tissue, ten or more cells in thickness.

The body is thus a colony of cells and may be compared to a brick building which is made up of so many individual bricks. Just as from a distance we cannot distinguish the individual bricks of a house, so also we cannot distinguish the cells of the body until we examine its tissues with the aid of a microscope. The microscope makes these tiny objects look hundreds of times as large as they really are. Without it we should still be ignorant of much of the wonderful structure and work of our bodies that we now know.

Summary.

The body consists of myriads of tiny cells that cannot be seen without the aid of a microscope. Cells are of different kinds, but similar cells combine to form a tissue. Tissues combine to form organs. Each tissue has a particular duty to perform in the organ: muscle tissue to contract and move the body, connective tissue to bind parts together, epithelial tissue to cover surfaces. Other kinds of tissues will be studied in later chapters.

Questions.

1. When I say, "The heart pumps blood," is this a statement of the physiology or the anatomy of the heart? 2. What is meant by physiology? 3. Anatomy? 4. Hygiene? 5. Sanitation? 6. What is an organ? 7. Name the cavities of the body. 8. Name and locate the important organs of the body shown in Figs. 4 and 5. 9. Tell how the microscope has been of service to mankind. 10. Describe muscle tissue; connective tissue; a cell. 11. Draw pictures of several kinds of cells.

CHAPTER XIX.

Why We Eat.

All the tissues of the body are built up out of the food we eat. This is one of the most mysterious things in all nature: how the simple articles of food which we eat day by day become transformed into the various tissues and cells which make up our bodies. To understand these wonderful things better, we must study the different foods we eat and their special uses. We wish to learn which foods build up the tissues and which have value to us in other ways.

All Animals Need Food.—Have you ever observed a mother bird feeding her little ones in her nest? How wide they open their hungry mouths and utter eager cries, while the devoted mother brings one worm, insect or seed after another to appease their appetites! What would happen to the helpless nestlings if the mother bird were killed is easy to imagine—they would starve to death. All animals must have food. You who eat your daily meals with regularity have perhaps not thought of the way animals have to struggle for a living, for they, like you, are always hungry. Consider how the following animals secure their food in the wild state: cats, wolves, deer, fish, birds, spiders, boll weevils, mosquitoes, bees, owls. Discuss them in class. A large part of an animal's time is spent securing food. The same is true of man. A reference to your text-book of geography will show you what a large part of man's time is spent in the raising, selling and transportation of plants and animals for food.

Why We Need Food.—If asked why we need food, different persons give different answers. "To nourish the body," "To

give us strength,'' ''To keep us alive,'' are among the answers one hears. Perhaps we may find simpler answers to the question why we eat.

The nestling bird is small and featherless, the puppy has many pounds yet to gain in weight, and you are not as large as you expect to be. Young animals and boys and girls **eat to grow.**

And yet we do not gain in body weight according to the weight of the food we eat. If you eat two pounds of food a day, how much do you eat in a year? In an average lifetime? Why, then, do we eat so much more than is needed for growth?

Perhaps if you were asked why you feed your horse more when he works than when he is idle; or if you were asked why you are unusually hungry after vigorous exercise you might answer that we eat to work. In other words, **food furnishes energy—it enables us to work.**

How, then, does the food furnish us energy? To answer this question let us first ask whence comes the energy to run a steam engine? From the wood that is burned under the boiler, you say. The stored-up energy placed in the wood by the tree is changed into active energy, heat, by the burning. The carbon in the wood unites with the oxygen of the air and in so doing produces heat. This uniting of oxygen with substances is called burning or oxidation.

Experiment With Carbon.—You have all seen charcoal. This black substance is an example of carbon. Coal is also largely carbon; and so is the ''lead'' of your lead pencil. Strike a match and let it burn until it is well scorched, then blow it out. The black you now see is carbon. There is, therefore, carbon in wood. Carbon will burn by uniting with oxygen, forming carbon dioxide. The carbon dioxide passes off into the air. Strike another match and as it burns state what happens.

In a similar way the body gets its energy from food. Green plants produce foods of various kinds, which are eaten by animals. Animals breathe in oxygen with the air just as a stove or a boiler of the engine takes in oxygen in the draft. In the body, as in the engine, the oxygen unites with the carbon which the food or fuel contains, and energy is given off—we are firstly enabled to do work, and, secondly, **we are kept warm.** The more we work the more we must eat. The faster we exercise the faster we must breathe to supply us with sufficient oxygen to "burn," and as a result of this increased oxidation our bodies become warmer. In all this our bodies are like engines. We may, therefore, say that we need food **to supply our bodies with energy for work and with heat to keep our bodies warm.**

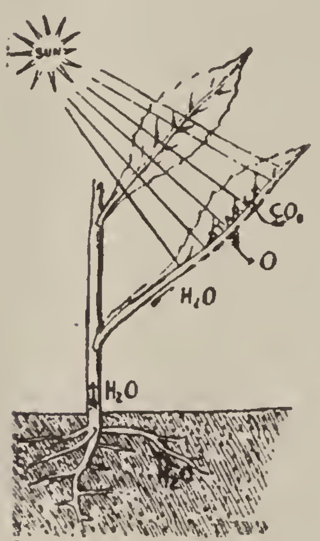

Fig. 84. Diagram illustrating the formation of the starch in green leaves.

In one regard, however, our bodies **differ** from an engine: the engine cannot repair itself. If a part breaks or wears out a new part must be supplied. Every part of the body is constantly wearing out, but the body repairs itself. In case of injury to the skin, new skin soon covers the wound. If a bone is broken, the fracture heals. Hair and nails and skin are continually growing to take the place of cells worn off. We need food, therefore, also **to repair worn-out parts of the body.**

Plants, Too, Need Food.—Plants are living things, just as animals are, and they, too, need food. Plants use food rather for growth, while boys and girls need it more for energy to get about with in their work and play. Think of how an acorn grows to be a giant oak. In a wonderful way all of the roots, trunk, limbs and leaves of the tree are built

up out of water and a few minerals from the soil and carbon dioxide from the air. The green part of leaves has the power of making starch out of water and carbon dioxide with the aid of sunlight, as indicated in the diagram, Fig. 84. How this is done and what the plant does with the starch in building up its own body you will learn when you study botany or agriculture. Animals and man make use of the starch and other substances in the plants, using them for food and thus indirectly also using the warmth of sunlight for their own bodies.

Summary.

Green plants, with the energy of sunlight, manufacture foods for animals and man. This food furnishes energy, enabling us to move about in work and play and keeping our bodies warm. The food containing carbon will burn like wood or coal by uniting with oxygen from the air. Food also furnishes material for growth and for the repair of injured or worn-out parts of the body.

Questions.

1. Make a list of the names of animals, and place opposite each the name of the chief kind of food the animal lives on. 2. Name four reasons why we need food. 3. Do we need more food in winter or in summer? Why? 4. Why do we need more food when we exercise than when we rest? 5. What kind of substance is carbon? 6. Name some substances that contain carbon. 7. What is the use of carbon in our foods? 8. What part do plants play in nature?

CHAPTER XX.

What We Eat.

All animals depend directly or indirectly upon green plants for food. Most animals live upon plants directly, as cattle, potato-beetles and plant lice. (Mention five others.) Some animals prey upon other animals, as wolves upon sheep and rats upon mice; but in each case the prey gets its food from green plants and so the wolf and the cat are dependent indirectly upon plants. Man eats both plant and animal food. Do you know of animals that do the same? Consulting your geographies, make a list of five important animals used by man for food, and where these are raised; ten important plants, and where these are raised. Make a list of twenty-five food products that you can buy at the grocery store. These studies will convince you that there are many kinds of food. Even the same animal will produce various kinds, as cattle, which furnish meat, milk and cheese. So all food of man comes from living things.

All of these kinds of food are really made up of but three classes of food substances. That is, all of the foods placed on the table before us to eat, or that we feed to our domestic animals, are mixtures of these classes: **carbohydrates**, **fats** and **proteids**. Carbohydrates, fats and proteids are called the **foodstuffs**, and these make up all of our food, whether derived from plant or animal.

The Carbohydrates, the sugars and starch, we get almost altogether from plants, and they are the cheapest of the foodstuffs. Starch is found in large amounts in most seeds, such as corn, rice, wheat, beans and peas; in the stem of the sago palm (sago); in roots and underground stems of manioc

(tapioca), sweet potato, Irish potato. Sugars are of different kinds: cane sugar, secured from sugar cane and sugar beet; and grape sugar, found in grapes and other fruits, but manufactured from cornstarch in large amounts. Cane syrup (molasses) and corn syrup, contain chiefly sugar and water. Honey and the sap of maple trees are also sources of sugar. Sweet corn and milk and most fruits contain some sugar.

Experiment With Starch.—One can easily find out whether a substance contains starch or not. Iodine turns starch blue. Make a thin starch paste by boiling a little starch in water. Add one drop of tincture of iodine (to be secured from any drug store) to a little starch paste in a test tube or a small bottle. Try this on crumbs of bread shaken up in water. Place a drop of the solution on a cooked potato; on a raw potato; on an apple, or on any other food you want to test for starch.

Experiment With Sugar.—If food is sweet it contains either cane sugar or grape sugar. The latter is easily found if present, because it causes a red color to appear when heated with Fehling's solution. Fehling's solution is a mixture of two solutions: A, a solution of bluestone, and B, a solution of soda lye. The solutions should be kept separate until they are used. They can be secured at the drug store and should be fresh. Grape sugar is found in corn syrup and cheap stick candy. Dissolve some of either in water. When ready to make the test, mix a quantity of Fehling's solution, by using equal parts of solutions A and B. Pour the mixed solution into a test tube to the depth of an inch. Bring to a boil, using an alcohol lamp and applying the flame to the top of the liquid, as shown in Fig. 85. Now add about fifteen drops of a solution of stick candy. The red color which will appear indicates grape sugar, for cane sugar will not act that way. Try this also on cheap cakes to see what kind of sugar was used in their manufacture.

FIG. 85.

FIG. 86.

Figs. 85 and 86. Showing two methods of heating liquids.

Experiment to show how grape sugar is made from starch.—Add a little hydrochloric acid to some thin starch paste in a test tube and heat it. Note that the liquid becomes clear. Test for sugar as in the last experiment. The acid has turned the starch into grape sugar.

Some Foods Rich in Fat.—Animals produce fats in their bodies. Meat, therefore, has more or less fat, that of beef being called tallow; of pork, lard. The cream of milk is fat; cheese, being made from milk, contains considerable fat. The yolk of eggs is largely fat. Nuts are usually rich in fats, as also are the seeds of the cotton plant and peanut and the fruit of the olive. There is not much oil in the grains, but corn contains more than the others. A fat that is liquid at ordinary temperatures is called an oil. Thus tallow is a fat; cotton seed oil is an oil.

Some Foods Rich in Proteids.—In selecting a meal we would not choose potatoes to go with bread and butter, but rather eggs or meat. Bread and potatoes furnish starch chiefly, and eggs and meat are largely proteid. The white of an egg, called albumen, is almost pure proteid, as is also lean meat. Milk is rich in proteid. In skimming milk we remove only the fats, leaving the proteid and sugar. The curd of the milk is the proteid. Seeds of the legumunous plants (peas, beans and peanuts) are very rich in proteids. Among the common grains, wheat contains most, rice least proteid.

Experiment With Proteid.—Shake up a very little white of egg in a test tube with some twenty drops of water. Add ten drops of concentrated nitric acid and warm the mixture over an alcohol flame. A yellow color appears. Add ammonia until effervescence ceases. The orange color that appears indicates the presence of proteid, in this case the white of egg. Try this on bread crumbs or other food.

Observations on Grains of Rice, Wheat and Corn.—Soak in water for twenty-four hours enough grains of rice, wheat and Indian corn to supply one or two of each kind to each pupil in the class. If

needed at once the seed may be boiled for a short time. Note the location of the germ or embryo (E) as shown in the outline sketches in Fig. 87. With a sharp knife cut the grains lengthwise through the germs along the straight lines indicated in the drawings. Study the cut side; make out the germ in the corner and the proteid and starch portions of the grain. The starch will be found white and softer than the more shiny and horny proteid portion of

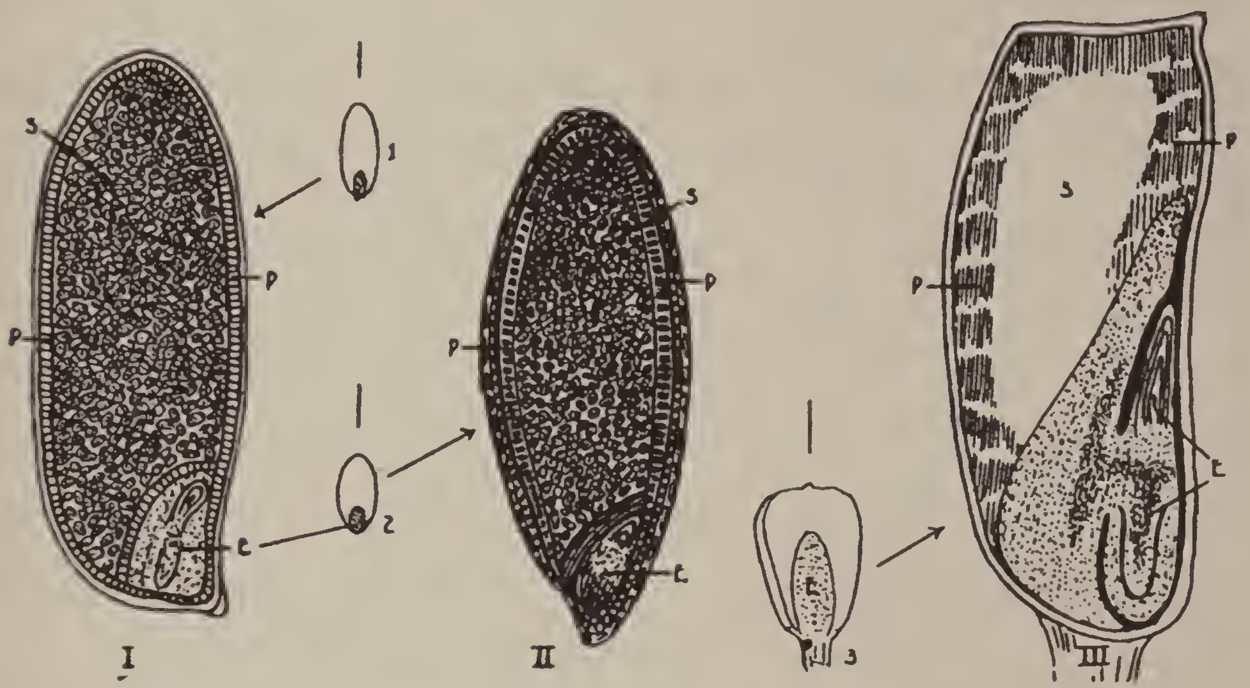

Fig. 87. Sections through seeds of rice (I), wheat (II) and corn (III), showing the proteid (P) and the starch (S) of the seeds, and their germ (E); 1, 2 and 3, the seeds as seen from the outside, natural size.

the seed. What kind of corn is it more profitable to raise: corn with seeds rich in starch or corn with seeds rich in proteid?

The Uses of the Various Foodstuffs in the Body.—All of the foodstuffs serve to produce heat in the body and energy for work, because all contain carbon for burning.* Fat is the best "fuel food" because it will produce the most heat and

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*You may easily prove that there is carbon in proteid and in starch and sugar by scorching them (in frying an egg or baking bread, for example). The black substance is carbon.

energy in the body. In what season of the year are fats most palatable, fat pork for example? In what region of the globe are fats and oils considered delicacies? Carbohydrates and fats serve only to produce heat and energy and are therefore called "fuel foods." Proteids serve this purpose also; but in addition to this they are the "tissue builders," that is, they are used for growth and repair of the living substance in the body.

Other Things Needed by the Body.—We prefer to call only those substances food that will burn, or that can be oxidized in the body. But for life and health other substances of the mineral kingdom are necessary. **Oxygen** is needed by all living things. It is found mixed with nitrogen in the air. We cannot live over a few minutes without breathing in a new supply of oxygen. It is needed to burn up the food in our bodies and to keep up the "fire of life." **Water** is almost as necessary for the body as oxygen. Almost three-fourths of the body is water. Besides drinking the water we get a great deal of it in our food. Over eighty per cent of potatoes, for example, and fifty per cent of beef consists of water. **Mineral salts,** particularly table salt, are essential to the proper working of the organs of the body. Lime is necessary for the bones, especially during growth, and iron for the red corpuscles. All of these minerals, except table salt, we usually find in sufficient amounts in our food. For example, all plants contain some lime, and iron always forms one of the constituents of green leaves.

Fig. 88. Ash is the mineral part of food.

Experiment to show that foods contain mineral matter.—Take

a piece of bread or meat, place it on a piece of tin, or, better, in an iron spoon (Fig. 88) and burn it over a fire. Examine the ashes. They are the mineral matter in the food.

Summary.

There are many kinds of foods that serve for man and beast the world over, some derived from plants and some from animals. These contain only three classes of foodstuffs: carbohydrates (sugars and starch), fats and proteids. Carbohydrates and fats are called the fuel foods since they serve only to be oxidized or burned in the body for the production of heat and energy. Fats are the best heat-producing foodstuffs. Proteids equal starch and sugar as a fuel food, but in addition build up the tissues, being used in the body for growth and repair. Certain minerals must also be taken with the food for the maintenance of health.

Questions.

1. Mention ten common foods. 2. Mention the main foodstuffs. 3. Are animal or vegetable foods the richer in carbohydrates? 4. Mention four foods rich in fats; six rich in proteids; eight rich in carbohydrates. 5. How can you test a food to find out if it contains starch? 6. What is the test for proteids? 7. Which foodstuff is the only tissue builder? 8. Why can all the foodstuffs furnish working energy and heat? (See question 7, Chap. XIX.) 9. Which is the best fuel food? 10. What should be a difference in the kind of our food in summer and in winter? 11. Mention the most important mineral foods. 12. How can you prove the presence of minerals in food?

CHAPTER XXI.

Pure Food.

To select foods wisely for a meal we should remember several important things: what foodstuffs the foods contain, for whom they are intended, whether or not they are free from disease germs, and how to get the greatest value for one's money.

A Mixed Diet.—Everyone knows that a person cannot live on eggs alone, and you now know that the reason is because eggs do not contain carbohydrates. All of you like candy, but you would soon grow tired of candy and ask for plain bread and butter and meat. It is not a good idea to live on any one kind of food. In other words, we need a "mixed diet." Milk contains all of the foodstuffs and is an excellent food; but it does not contain them in the right proportion. As a rule, we need twice as much proteids as fats and nine times as much carbohydrates as fats.

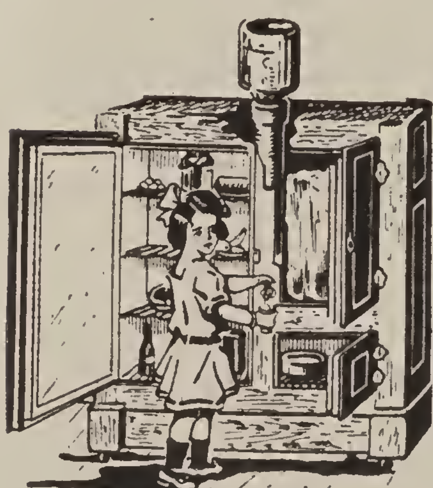

Fig. 89. Refrigerator. Food should be kept cold to prevent decay.

The proteids are especially useful for building up our bodies, and growing children need plenty of proteids. Any one who is recovering from a spell of sickness will need much proteid as soon as it becomes safe for him to have it. Of fats we should eat more in cold weather than in warm, for reasons stated in a previous chapter. Starch and sugar are useful

to furnish working energy and warmth. They should make up the bulk of what we eat.

***Eating Habits.**—Now, let us talk of something particularly practical, and something you can remember easily. How many meals a day do you have at home? Three? Why do people usually have three meals a day? It is probably habit, and it is a fairly good habit, but surely not all of us are exactly alike; for there are some boys especially that get hungry between meals and often eat candy. Children ought to eat between meals if they get hungry. They should be trained gradually to habits of regularity, but each pupil should be treated according to his own needs. Children can be trained to take a sandwich or a slice of buttered bread between meals instead of the candy they so often want. Candy is harmless in moderate amounts, but is best eaten at a regular hour when other food is taken. Colored candy is harmful in many cases.

The Cost of Foods.—The foods that cost least per pound are not necessarily the cheapest. Thus corn meal is cheaper than wheat flour, but it contains less proteid. In purchasing food we must take into consideration the amount and the proportion of the foodstuffs as well as the price per pound. Cheese is more nutritious than oysters, and cheaper. Peas and beans are very cheap and nutritious articles of food. It is necessary, however, to take into consideration also the individual tastes in the matter of selecting foods, as food must be appetizing and must "agree" with a person to be of greatest value.

Buying Food in the Market.—We now come to a subject of

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*Many children do not take sensible lunches to eat at school, but buy candies and pastry instead. This habit is bad and leads to indigestion and to poor progress in a pupil's studies.

especial interest to the girls. The place where most can be done in improving our food is in buying it at the market. There are many good things to eat that can be bought if you only go to market to find them. But if you merely telephone, the market man will, of course, see that you are not particular

Fig. 90. Cooking is so important that the subject is taught in many schools.

and will send poor food. He may have some good vegetables that you would like if you saw them, but he does not know you desire them, and in fact you do not. But if you saw them you might want them instead of something else. In buying always say, "Let me see it first."

If you are too busy to go to market, then always inspect the food as soon as it is received and return that which is not

fresh and good. The market man will furnish just as good food as the women demand. There is plenty of good food material to be had in Texas, and if our housekeepers pay attention to the food as it is bought they can get good food. In buying fish and meats especially, great care is necessary; also in buying fruits and vegetables. Think of the number of overripe tomatoes that are placed on the table in Texas in the course of a year. The only way to avoid this is by looking at the tomatoes closely, and this should be done at the time they are bought. Those who are interested may learn the names of the cuts of beef from the numbered diagram, Fig. 91.

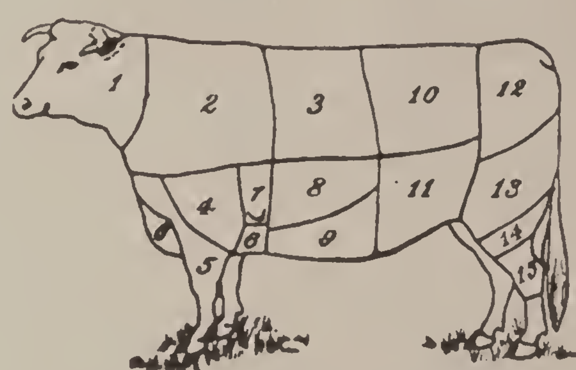


Fig. 91.—The cuts of beef: 1, neck; 2, chuck; 3, ribs; 4, shoulder clod; 5, fore shank; 6, brisket; 7, cross ribs; 8, plate; 9, navel; 10, loin; 11, flank; 12, rump; 13, round; 14, second cut round; 15, hind shank.

Lucretia Borgia, an Italian noblewoman, was said to have poisoned many people, but they were her enemies. We poison people today, but they are our friends and guests. We do it from carelessness in selecting the food. Have you not heard of the dreadful ptomaine poisoning which kills so many people, especially after they have eaten fish? Many of these cases could have been prevented by a little care in inspecting the fish when they were bought. Many of you say that you do not know how to tell good fish or meat when you see it. But if you try, you will find that you can do so. There is a fresh fishy odor about all fresh fish, but there is a putrid odor, an odor of decay, which surrounds the decaying fish.

Canned Foods.—Canned fish and canned meats are dangerous, because a pinhole, too small to be seen, may allow germs to get in and cause the decay of the meat. Dr. Wiley says that canned vegetables are not dangerous as a rule, but that canned fish and canned meats are always subject to suspicion. A young man in Austin ate some canned salmon at 3 o'clock one afternoon, and died of ptomaine poisoning the next morning. Many people are thus made sick but do not die. The canned goods, however, should be eaten with care and some uneasiness. Sometimes canned goods in putrefying form a gas which presses out the top and bottom of the can, causing what is known as "swell head." (Fig. 92.) It is unnecessary to say that such a can should be strictly avoided. Canned vegetables are more of a necessity in the North than they are here. Texas needs some progressive men to develop the various vegetable industries just as the onion industry has been developed in the Laredo country.

Fig. 92. "Swell head." Bacteria sometimes cause decay of canned foods, especially meats; the can may "swell" from gases on the inside.

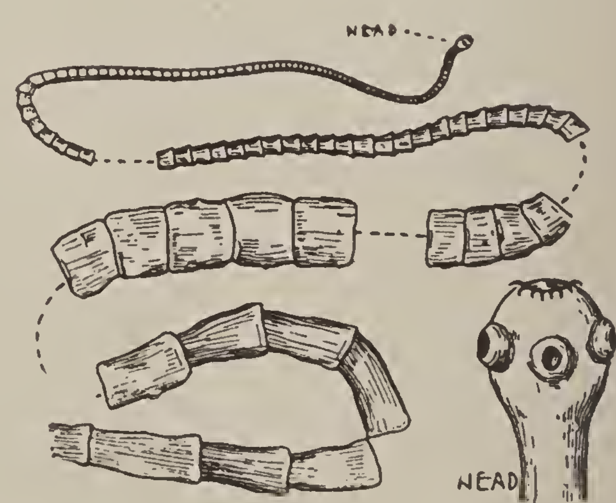


Fig. 93. Portions of a tapeworm with its "head" enlarged.

Cooking.—Most foods are improved by cooking (baking, boiling, broiling, stewing, etc.) for the following reasons:

1. Heat destroys the bacteria, which you have learned are likely to be present in food. It also destroys certain worm parasites like trichina in pork (Fig. 94), or tapeworm larvae in pork and beef (Fig. 93).

Fig. 94. A trichina from a muscle of the eyelid.

2. Cooking makes most foods more appetizing. An appetizing appearance and pleasant flavor of foods aid digestion in that they stimulate the digestive glands.

3. Cooking usually renders foods more easily digestible. In the case of vegetable foods we find that the plant cells have very thick and undigestible walls, and that the starch and proteid grains (Fig. 95) have tough skins around them. Heat breaks up the starch grains and the plant cell (Fig. 96), so that the digestive juices can get to the food material. In the case of meats, heat causes the connective tissue to swell and soften, but it does not make the muscle tissue of the meat more digestible.

FIG. 95.

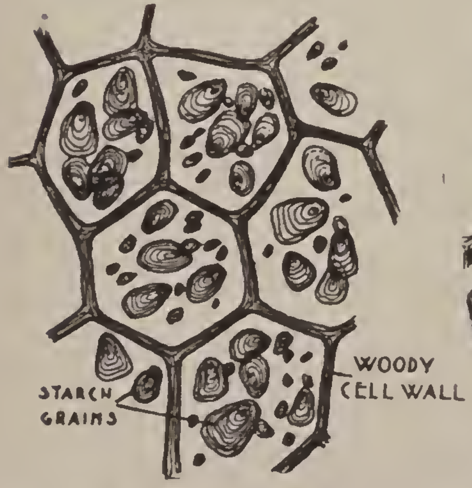
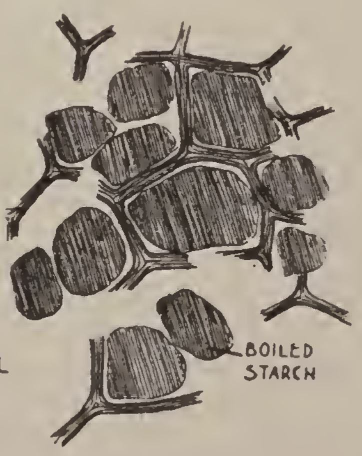


FIG. 96.



Figs. 95 and 96. Uncooked and cooked potato cells, magnified.

It should be remembered that heat hardens proteids like muscle tissue and the white of eggs and makes them harder to digest. White of eggs is more easily digested soft boiled than hard boiled. Grease renders foods less digestible.

Milk as a Food.—Milk is one of the most nourishing of all foods. It forms an especially large part of the food of young children, old people and invalids. Milk contains all of the foodstuffs in nearly the right proportions. When intended for babies under two years old, milk should be prepared by adding certain foodstuffs to it to make the proportions exactly right. This should be done under the advice of a phsician. Babies do better on cow's milk than on the patented foods advertised. Since, then, milk is so important as a food it behooves us to see to it that our milk supply is clean and pure.

Bacteria in Milk.—Because milk is very nourishing bacteria will thrive and multiply in it after they once get a start. There are many adulterants which dishonest people add to milk; but the most dangerous things that we find in the milk are the harmful bacteria. More epidemics of disease have been spread by milk than by any other food. Up to 1909, two hundred and eighty different outbreaks of disease had been definitely traced to milk as a cause of spread. Most of these were typhoid fever epidemics, but scarlet fever and diphtheria also occurred in epidemic form because of the presence of disease germs in milk. Milk is especially connected with tuberculosis, because cattle are affected by that disease, and tuberculosis is the commonest disease in the world. In view of these facts it is well to learn how milk can be kept free from dangerous germs.

The Cow.—First, the cow herself must be healthy. In many states, one-fourth of all milch cows are affected with tuberculosis. In Texas, however, the tests made by the Dairy and Food Commissioner show that only one cow in a hundred is affected. Children can contract bone and gland tuberculosis from germs in milk, and hence they should never

drink milk from cows that have not been tested and found to be free from tuberculosis. The most healthy looking cow may have the disease. Fig. 97 shows a cow in apparently good condition, but when tested she was fonud to have tuberculosis.

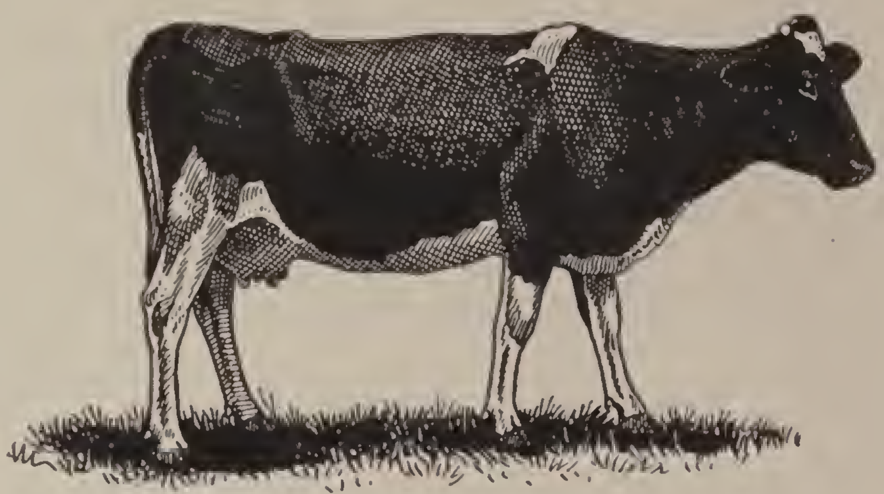
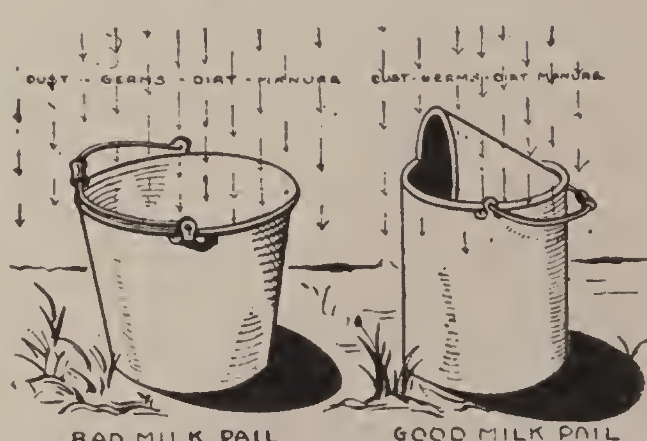


Fig. 97. This cow, though healthy in appearance, was found to have tuberculosis.

Milking.— In milking we should do all we can to prevent bacteria from getting into the milk. Most bacteria are, of course, kinds that are harmless unless present in very large numbers. So great care of the milk should be taken, so that in twenty-four hours there should not be more than 300,000 bacteria to the thimbleful. If carelessly handled the milk may be a "germ soup," containing 3,000,000,000 to the thimbleful. There are several points important to remember in milking:

FIG. 98. FIG. 99.



Figs. 98 and 99. A bad and a good kind of milk pail.

(1) No person who has had typhoid fever within twelve months should be allowed to handle the milk, unless a physician has made a test and pronounced the patient free from danger-

ous germs. A "typhoid carrier" would infect the milk with his hands. Every milker should wash his hands with soap and water before milking. (2) Dust carries many bacteria into milk. To prevent this the cow's udder should first be washed. A milk bucket with a small opening, as shown in Fig. 99, and not one of the kind shown in Fig. 98, should be used. If the milk is intended for the baby, it is well to milk through a scalded cheese cloth stretched over the bucket. It is, of course, needless to add that flies should be kept from wiping their feet on any of the milk vessels.

Care of the Milk.—Germs will not grow and multiply rapidly in the cold. The warm milk from the cow should be cooled at once after straining, and should be kept on ice. In case ample cooling facilities are not at hand, at least milk intended for the baby should be kept cold until it is to be used, when it can be quickly warmed. Fig. 100 shows a simple, inexpensive form of a home-made ice box. The milk room should be screened and free of flies.

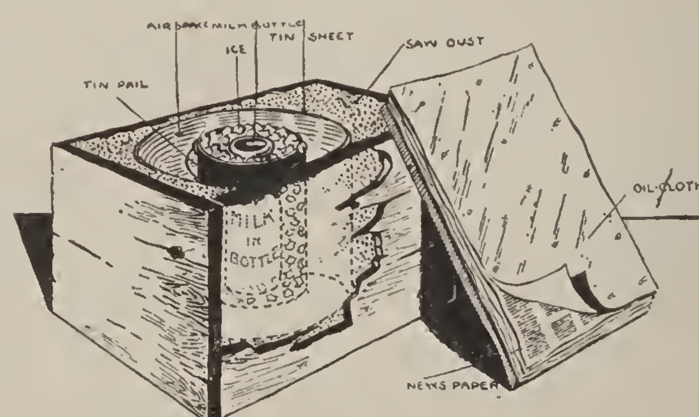


Fig. 100. A home-made ice box for keeping bottles of milk cold and sweet.

Dairy Inspection.—When a person owns his own cattle, it is a comparatively simple matter to have everything connected with the care of the milk clean and sanitary. Those who get their milk from a dairy, however, find it hard to get milk that has fewer than 300,000 bacteria in a thimbleful. It is well to patronize a dairy that you know is sanitary, and it is well to pay the dairy an occasional visit. The women's clubs can do

a great deal to secure proper laws for the regulation of the milk supply and to see to it that these laws are enforced.

Summary.

In leaving this chapter remember the following points:

1. Care should be taken in the selection of food. In planning a meal we should select a variety of foods so that all of the foodstuffs be represented.
2. Above all, we should select food free from disease germs.
3. Canned foods should be looked upon with suspicion, for they often contain poisonous germs.
4. Cooking kills germs and makes many foods, particularly most vegetable foods, more digestible and more palatable.
5. Milk is so important a food and so often contains dangerous germs that every care should be taken to secure pure milk.
6. Milk is infected with dangerous germs from dust, from flies and from the milker's hands and throat.
7. Germs usually harmless may become harmful to children and invalids when present in numbers more than 300,000 to the thimbleful.
8. Milk should be drawn into a bucket covered with a scalded cheese cloth, and should be strained and put on ice at once.

Questions.

1. What is meant by a mixed diet? 2. Select for a dinner five foods that shall together constitute a mixed diet. 3. Why is it better to eat something substantial for a school lunch than mere candy or pie? 4. What are the most harmful things that get into food? 5. Discuss the danger from canned foods. 6. State three advantages

of cooking food. 7. What foods should be cooked long and at a high heat? 8. Why is milk an important food? 9. Why may milk be also a dangerous food? 10. What diseases are known to be scattered by infected milk? 11. Why should milch cows be tested for disease? 12. Discuss fully how we can prevent bacteria from getting into milk. 13. Why should milk be kept cold? 14. How could you make a cheap ice box sufficiently large for keeping several bottles of milk? 15. What does Fig. 97 illustrate?

CHAPTER XXII.

Getting the Food Ready for the Blood: Digestion.

The proper selection of the food in the market and its preparation in the kitchen is important; but the food is even then not ready for the blood. In the mouth and the food-tube the food is changed very much. It is ground up, mixed with juices and becomes quite liquid before the blood receives it to carry it to all parts of the body. The following experiments should be performed to illustrate the changes the food undergoes in the body:

Preliminary Experiments.—(1) Take two tumblers half full of water. Into one place a lump of salt (table salt); into the other drop the same amount of salt that has first been powdered by grinding in a mortar or with the head of a hammer on a smooth board. In which tumbler does the salt dissolve the faster, and why? To another tumbler add a little starch. Does this dissolve like the salt? The salt is said to be **soluble**; the starch **insoluble**.

(2) Again procure three tumblers with water, a quantity of hydrochloric (muriatic) acid and two small pieces of limestone or marble about the size of a pea. Drop one piece of limestone into tumbler No. 1 (Fig. 101). To both the other tumblers add a little acid. To tumbler No. 2 add a piece of marble in a lump; pound the other piece of marble to small bits and add them to tumbler No. 3.

Fig. 101. Limestone dissolving in acid.

Tumbler No. 1 has water and a lump of marble only. Tumbler No. 2 has water and a lump of marble with acid. Tumbler No. 3 has water and fragments of marble with acid. Now observe the results. (Add acid to Nos. 2 and 3, if bubbling should cease before the limestone is dissolved). Putting together the re-

sults of the foregoing experiments we note:

1. That salt is soluble.

2. That starch is insoluble.

3. That limestone is insoluble.

4. That acid will change limestone into a form that is soluble in water.

5. That salt in small particles is more readily dissolved than when in lumps.

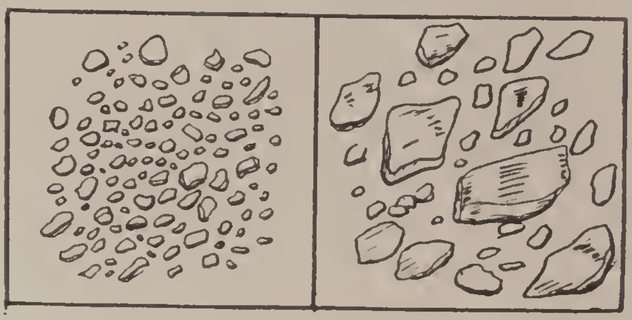
6. That limestone is acted on faster when in small particles than when in a lump.

Digestion Defined.—The preparation of food in the body for the blood is called the digestion of food and may be compared to the action of acid on limestone in these experiments. The insoluble limestone is made soluble by the acid. In the experiment to illustrate the manufacture of grape sugar from starch (page 136), starch was digested by acid and heat. **Digestion, then, may be defined as the process of rendering the food soluble in the body.**

Mechanical Digestion.—There may be said to be two sides to the digestive process. The experiments just described show us (see conclusion 5) that the limestone will be acted on faster when ground fine than when in a lump. Grinding up the limestone does not change it into a new substance, but simply makes the lumps smaller, for a piece of limestone is limestone still. Such a process is said to be mechanical. Thus we speak of mechanical digestion, the breaking up of the food into fine particles. This is performed mainly by the teeth, which cut, tear and grind the food into very small particles. (Fig. 102.) **Chewing** the food is extremely important. To eat a meal in a hurry, swallowing the food in large lumps (Fig. 103), is

very injurious and may cause indigestion and various other ailments. If food is improperly chewed, it is so slowly digested that it is likely to decay or sour before it can be fully digested. Chewing is also good for the teeth, for unless they are used a reasonable amount they will decay.

FIG. 102. FIG. 103.



Figs. 102 and 103. Well chewed and poorly chewed food, magnified.

In the mouth the food is also moistened with saliva, which aids in swallowing. To show how hard it is to swallow dry food crush a small cracker and try to swallow it quickly. Then try one soaked in water. The churning motion of the stomach is also an important part of mechanical digestion. Note the direction of the muscle fibers in the walls of the stomach shown in Fig. 114.

Chemical Digestion.—When, however, in the experiment, acid has acted on the limestone, it is limestone no longer, but a different substance, and the new substance is soluble. Similarly, when starch is heated with an acid it is starch no longer, but is changed to grape sugar. Such a change is called a **chemical change.** In the body these changes are not brought about by strong acids or great heat, but by certain substances in the digestive juices, like the saliva in the mouth. The action of this juice on starch is the same as that of acid and heat: saliva changes starch to sugar. Such a change is called a chemical change, and the process in the body is called chemical digestion. The active agents of the digestive juices that bring about chemical digestion are called **enzymes.** Each enzyme acts on a single kind of foodstuff. For example, **ptyalin** is the enzyme in saliva that changes starch to sugar. The

most important enzymes are given in the table at the end of this chapter. The chemical digestion of starch by saliva can be studied very nicely in the following experiment:

Experiments to prove that starch is changed to sugar by saliva.—(1) Taste a piece of clean wood; chew it a little. Does it taste sweet? Take a piece of cracker soaked in water and note whether it tastes sweet the moment it is taken into the mouth; or does it at first taste like wood? Chew it and note the result. Why does the wood not taste sweet as does the cracker after it is chewed a while? (2) Let one of the pupils chew half of a cracker for a few minutes. Have a small portion of the now nearly liquid contents of his mouth placed in a test tube. Add Fehling's solution and boil as in the experiment on page 135. The red color proves that a large amount of sugar is present.

Thus starch must be changed to sugar before the blood can take it up. Proteids are changed to soluble proteids called **peptones.** Fats are also digested. The first step in the digestion of fats is similar to the making of soap. In the making of soap, fat and lye are put into a pot and boiled. In the human intestine a kind of "soap" is made out of the fats of our food and soda there present. After some soap has been made this can digest more fat by "emulsifying" it, that is breaking it up into very small particles. Fat in this condition is called an emulsion. As an emulsion it can be taken up by the blood. Milk is a good example of an emulsion. A drop of milk seen under the microscope would show tiny drops of fat, as pictured in Fig. 104.

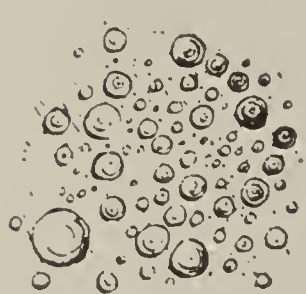


Fig. 104. Oil globules in milk.

Experiment to Illustrate How Fats Are Emulsified.—Take two pint bottles and pour a little oil (cottonseed oil will do) into each, so that some oil will stick to the sides of the bottles. To one add plain water; to the other, soap and water. Now let two boys shake the bottles. In which bottle do the oil and water mix well? In which

bottle does a layer of oil collect on top or continue to stick to the sides of the bottle? Why?

Summary.

Digestion of food in the body consists of changing insoluble into soluble foodstuffs: starch is changed to sugar, proteids to peptones and fats are emulsified. These changes constitute chemical digestion and are due to the various digestive juices. The process is hastened by the thorough chewing of the food, or mechanical digestion.

The following summary of chemical digestion will prove helpful:

Digestive Organ	Juice	Enzyme	Digests
Mouth	Saliva	Ptyalin	Starch
Stomach	Gastric Juice.	Pepsin (Rennin)	Proteid (Curdles Milk)
Small Intestine	Pancreatic Juice	Trypsin Amylopsin Steapsin	Proteids Starch Fats
	Intestinal Juice	(Invertin)	(Cane Sugar)

Questions.

1. Define soluble; insoluble. 2. Mention several soluble and several insoluble substances. 3. What does Fig. 101 illustrate? 4. Describe an experiment illustrating digestion. 5. Define mechanical digestion. 6. Describe an experiment that shows the value of chewing our food. 7. What is meant by a chemical change? Illustrate. 8. In the experiment with saliva, how can you prove that the starch has been changed to sugar? 9. Where are enzymes found, and what work do they do? 10. Name the digestive juices. 11. How are fats digested? 12. Mention the foodstuffs that have to be digested, and tell what each is changed into in digestion. 13. How can we study real globules of oil like those pictured in Fig. 104?

CHAPTER XXIII.

Where Digestion Begins: The Mouth.

The organs of digestion are the various parts of the food-tube or alimentary canal and the several organs called glands that communicate with the alimentary canal. This begins at the mouth. The other organs can be seen in Fig. 80. Draw Fig. 105 on paper or on the blackboard, and, after comparing it with Fig. 80a, name the digestive organs on your drawing.

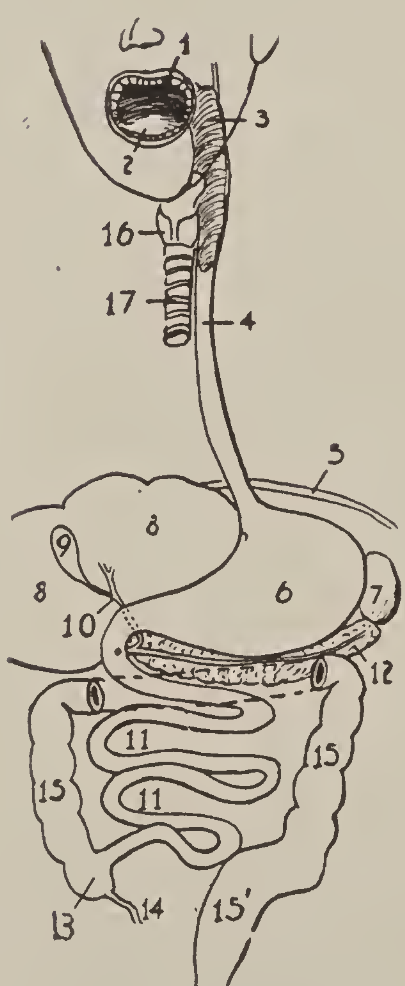


Fig. 105. Outline of the principal digestive organs.

The Mouth.—Name the organs found in the mouth. What bounds the mouth on the sides? in front? The roof of the mouth is called the **palate** (Fig. 106); the hard palate nearer the front. can be touched by the tongue pressed upward; the soft palate, farther back, ends in a flap called the **uvula**. The mouth communicates behind with the throat or pharynx and is partly separated from this by the soft palate. Study Fig. 106. Then try to see the named organs in your mouth, holding a hand mirror before you and standing toward the light. How large is the mouth cavity? To answer this question close the mouth and "feel" whether or not the tongue fills the mouth completely when closed.

Chemical Digestion in the Mouth.—Review the chemical action of saliva on starch. The saliva is produced by three pairs of **salivary glands** placed as shown in Fig. 107. These glands empty their juice, the saliva, through openings on the inside of the cheek (DP) and under the tongue (DS). A further use of saliva is to moisten the food to enable us to swallow. Saliva also keeps the inside of the mouth continually moist.

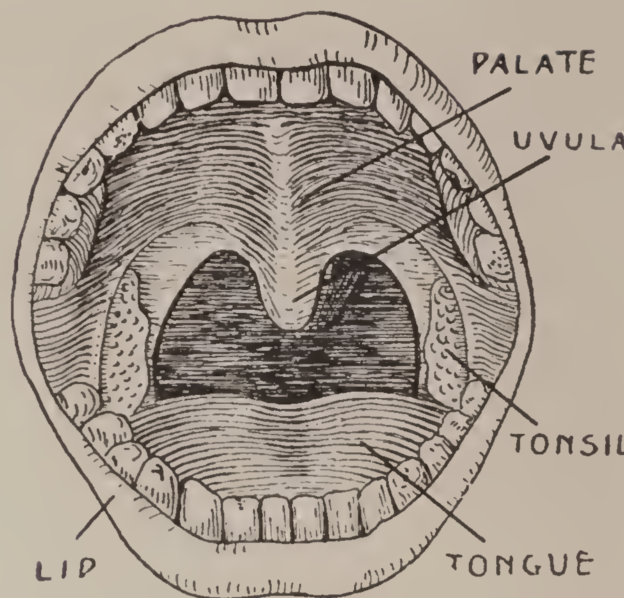


Fig. 106. The mouth cavity.

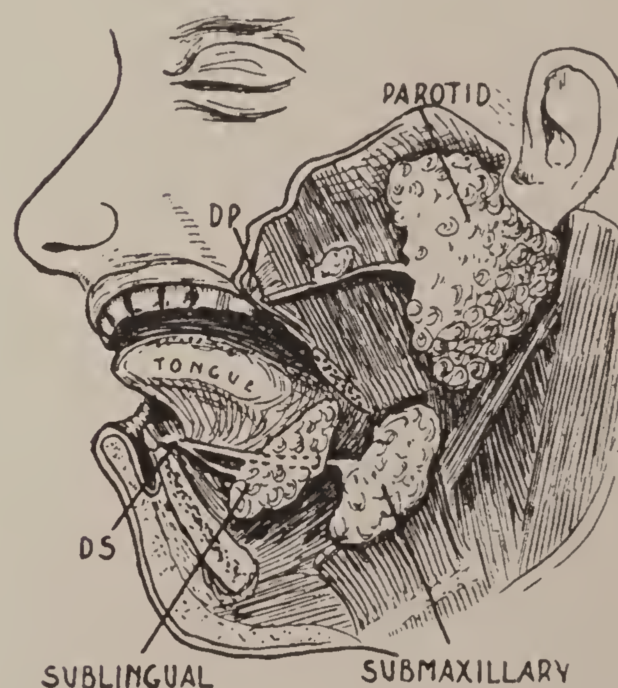


Fig. 107. The salivary glands of the left side.

The tongue is a muscular organ attached at its posterior end to the tongue-bone* (Fig. 133). Chew a mouthful of food and note exactly how the tongue "handles" it. Place a little salt on the tip of your tongue; can you taste it without drawing the tongue back? What letters of the alphabet are made in

*You can feel your tongue bone by pressing tightly with thumb and index finger against the sides of the throat high up under the lower jaw.

speech mainly by the tongue? by the lips? by the teeth? State three functions of the tongue suggested by these questions.

The teeth number thirty-two in the adult human beings—Fig. 109 gives the outlines and names of the teeth of the upper and of the lower jaw: two incisors, one canine, two premolars (or bicuspids) and three molars in each half jaw. Every person has two sets of teeth in his lifetime, those mentioned being in the permanent set. These begin to come

FIG. 108.

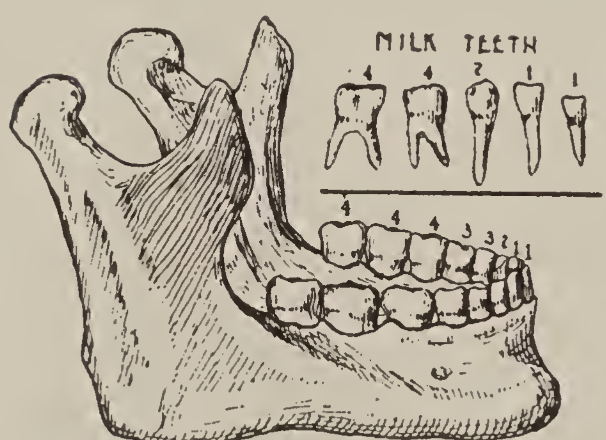


FIG. 109.

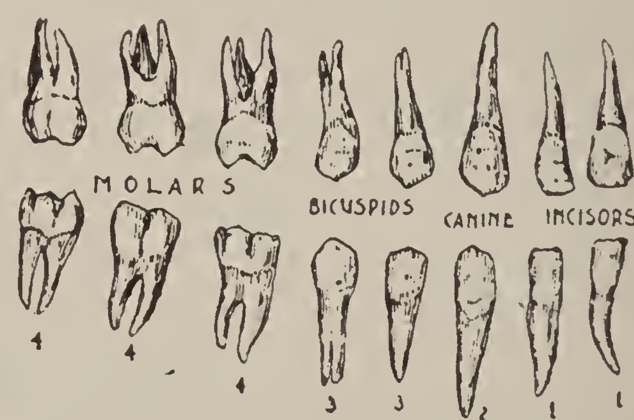


Fig. 108. The teeth of the lower jaw in place; the temporary, or "milk" teeth of one half of a jaw.

Fig. 109. The teeth of one side of both upper and lower jaws.

at the age of five or six, pushing the earlier or temporary teeth out (the so-called milk teeth). Do you remember losing your milk teeth? When did you lose the last one? There are only twenty-eight milk teeth (eight incisors, four canines and eight molars, Fig. 108), enough for a small pair of jaws. As the child grows so does the jaw, and more teeth are needed. Since the teeth cannot grow, a new set is formed. Why do not all of the milk teeth fall out at once? How many teeth have you? If you are between thirteen and twenty-one years of age you probably have twenty-eight, for the last

molars (the "wisdom" teeth) do not appear before that time.

With a mirror study the shapes of your teeth and determine from their shapes what each kind of tooth is for: whether for cutting or for tearing or for grinding. How do the incisors of the lower jaw move over those of the upper in chewing? If possible, examine the incisors of a gnawing animal, as a rabbit, squirrel or mouse; the teeth of a dog or a cat; the molars of a horse or a cow. What is the relation of the shape of the teeth to flesh-eating or plant-eating habits of animals? According to his teeth what kinds of food is it natural for man to eat?

Structure of a Tooth.—The only part of a tooth visible is the **crown,** which is covered with a hard, shiny substance, the enamel, the hardest substance of the body. The **roots** fit into sockets in the jaw bones. The gums cover the bones and come up a little distance on the tooth; this part of the tooth is termed the **neck.** The root is covered with a **cement,** a bony tissue, not so hard as the enamel. Underneath the enamel and cement, forming the bulk of the tooth, is the bone-like **dentine,** which surrounds the **pulp cavity**. This cavity or hollow is open at the tip of the root and is filled with connective tissue, nerves and blood vessels. The relation of these parts can be understood better by reference to Fig. 110, or still better, by studying a section of a real tooth.

Observation Work on a Tooth.—Secure a molar tooth of a horse or a cow (as these are large); or ask a dentist for a human tooth. A tooth not too old and dry is to be preferred. Have a blacksmith saw this in two with a hack saw. Then for a few minutes vigorously rub the cut surface of each half on a whetstone, using plenty of water. The two halves should now clearly show the parts of the tooth.

Care of the Teeth.—What are the uses of the teeth? Review the experiments on page 151 and state again the importance of chewing the food. The health of the other digestive organs, and therefore of the whole body, depends upon the preservation of the teeth. Furthermore, since we have but one set of teeth for the rest of our lives after the thirteenth year, it behooves us to preserve them. Picking the teeth with a hard instrument, as a knife, fork or pin, or biting a hard object, as a nut, should be strictly avoided; for the enamel is not one solid piece, but thousands of six-sided prisms set close together, like the bricks in a pavement. These are shown in surface view at E, Fig. 110. If some of these prisms are broken out, others will soon follow. Extremely hot or cold food should likewise be avoided.

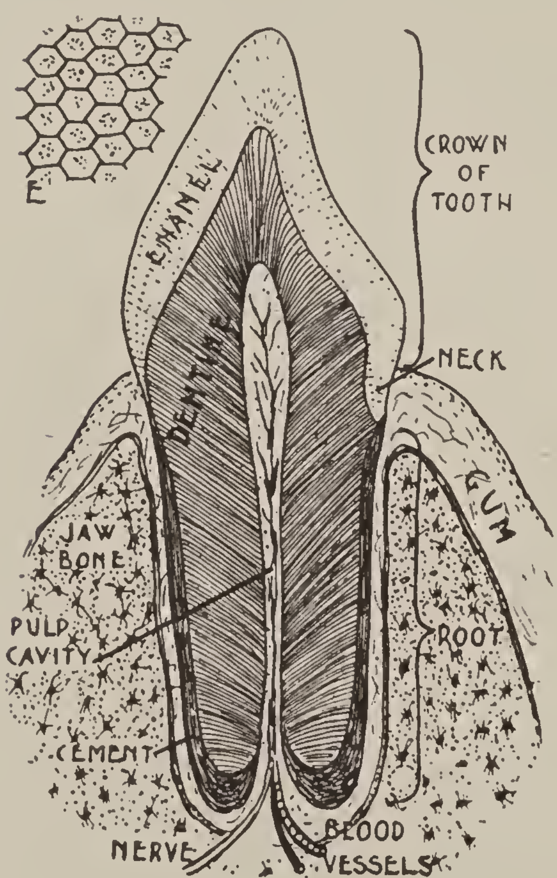


Fig. 110.—Section of a tooth, showing its parts. E, surface view of the enamel, highly magnified.

A tooth consists largely of limestone. Review the experiments with acid and limestone, page 151. Strong acids decay the teeth quickly and weak acids will do so in time. Now, in the mouth there are many bacteria that produce acids out of food substances left there from the meals. The teeth should, therefore, be kept scrupulously clean, that is, free from food particles. Gentle brushing of the teeth after each meal is the only safe rule to follow. Without food to live on the

bacteria could not exist in the mouth. Pretty teeth in a smiling mouth are also pleasant to look upon.

Any injury to the teeth or decay should be repaired promptly. If possible, a damaged tooth should be saved. The upper and the lower set of teeth fit nicely upon one another. When a tooth is pulled, the gap causes the other teeth to change their position in the jaw so that the two sets of teeth no longer fit as before. Misshapen teeth should be straightened, for this increases their efficiency and improves one's personal appearance.

Summary.

The teeth are so important as organs of digestion that everything should be done to preserve them. Brushing the teeth to remove particles of food prevents the growth of acid-forming bacteria and thus helps to prevent decay. All defects of the teeth should be corrected promptly by a dentist.

Questions.

1. Name and locate the digestive organs. 2. Mention the parts that can be seen by looking into the open mouth. 3. Describe the digestion in the mouth. 4. What are the uses of the tongue? 5. Locate the salivary glands and tell where the duct of each opens into the mouth. 6. Point out the different kinds of teeth in your mouth (compare Figs. 108 and 109). 7. Describe the structure of a tooth from an outline figure placed on the blackboard. 8. Why will acids dissolve the teeth? 9. How do bacteria cause decay of the teeth? 10. Give reasons why the teeth should be preserved. 11. State several rules of hygïene regarding the teeth.

CHAPTER XXIV.

Digestive Organs Continued—Gullet, Stomach and Intestines.

As the food is swallowed it passes through the pharynx or throat (Fig. 105) into the gullet or esophagus. This organ is nearly straight and leads directly to the stomach. The stomach has the greatest diameter of all parts of the alimentary canal, and its walls are thickest. Joining the stomach at its

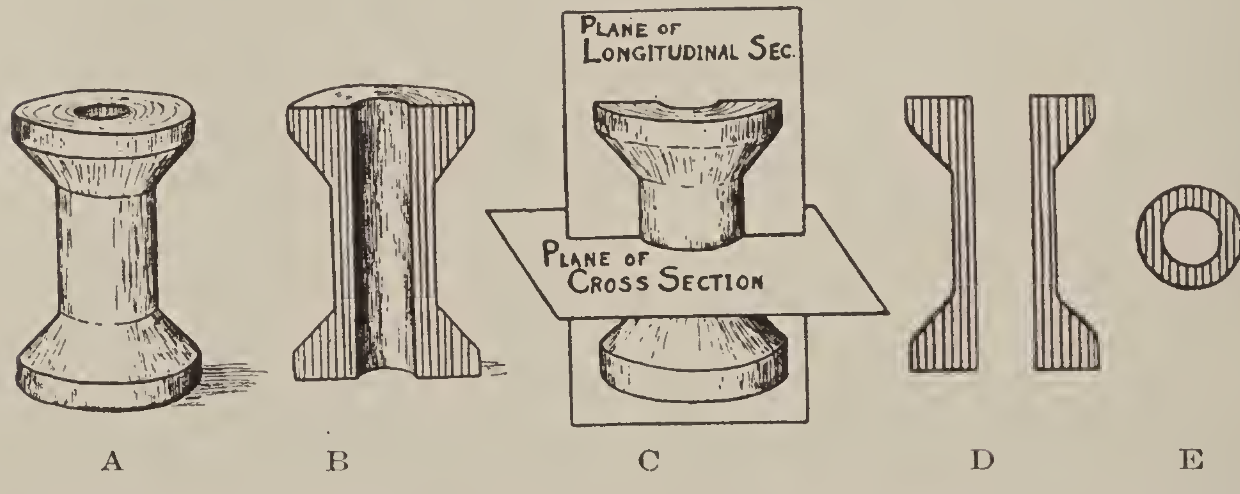


Fig. 111.—A, a spool; B, half of a spool cut longitudinally; C, manner of cutting spool to get D and E; D, a longitudinal section; E, a cross section.

lower end is the small intestine. This is by far the longest part of the canal, measuring from twenty to thirty feet in length, which necessitates its being coiled up in the abdominal cavity. The small intestine joins the large intestine in such a way as to leave a "blind sac" (13, Fig. 105). To this is attached the "vermiform appendix," (14), a useless organ.

When this becomes diseased the patient is said to have appendicitis*

The Alimentary Canal a Hollow Tube.—Thus from the throat on the alimentary canal is a hollow tube, very much the same in all parts. All of the organs, gullet, stomach and intestines, are made up of the same kinds of tissues. This can be studied in cross sections and longitudinal sections. (See Fig. 111 for meaning of these terms). Fig. 114 represents a stomach and adjoining parts of the gullet and small intestine, with portions of each cut away so as to show the structure.

The gullet is not very likely to become injured or diseased. The commonest disease of the gullet is scarring from concentrated lye swallowed by mistake. The scars contract and make the gullet so narrow that not even water can trickle through.

The walls of the alimentary canal are made up largely of muscle, an outer layer running lengthwise and a thicker inner layer running in rings around the canal. It is by the action of these muscles, especially of the circular or ring muscles (1, 2 and 3, Figs. 113-115) that the food is forced along the

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*Appendi̇citis begins with redness and swelling of the appendix. The swelling of the walls of the appendix may plug up the hollow space inside. If this plugging-up occurs near the end of the appendix that leads into the large intestine, a lake is formed in the appendix which has no outlet. Pus germs, growing in this closed space, form gas, which stretches the appendix and may burst it. If the appendix bursts or ulcerates through, the pus germs inside flow out into the abdominal cavity and the inflammation may spread, causing peritonitis (page 166). A large proportion of all pain low down in the right side is due to appendicitis. A physician should be called promptly in these cases.

canal. These muscles successively contract behind the food, so that a wave-like motion passes along the canal. This can be seen by observing the throat of a horse drinking water in a creek. The waves running along the neck of the horse (Fig. 112) indicate the passage of each swallow of water up the gullet. This motion is called **peristalsis,** and occurs all along the alimentary canal. In the stomach the muscle fibers run also diagonally, allowing more varied motion, the "churning" of the stomach.

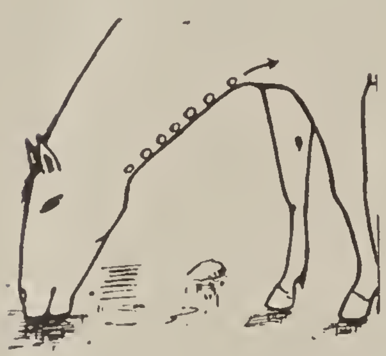

Fig. 112. Ring muscles carry swallows of water up the horse's throat.

Where the stomach connects with the small intestine the ring muscle is unusually thick. When this contracts it closes the opening so as to keep the food in the stomach, just as a lady's handbag is closed by pulling the strings. When the muscle relaxes the food may pass from the stomach into the intestine. This muscle, then, acts like a valve. It is called the **pylorus** (Fig. 114), or "gate-keeper," of the stomach. Its action may be further illustrated by puckering up the mouth as in the act of whistling, for there is just such a muscle* around the mouth.

Besides the thick circular layer the alimentary canal has a layer of epithelial tissue as a lining and one as a covering. The lining is called **mucous membrane.** It is only one cell thick (A, Figs. 120 and 121) in the stomach and the intestine, but much thicker in the mouth and the gullet. It is red from the presence of much blood so close to the surface. The covering (1, Fig. 114) of the stomach and the intestines is called the

*Such ring muscles controlling openings are called sphincter muscles.

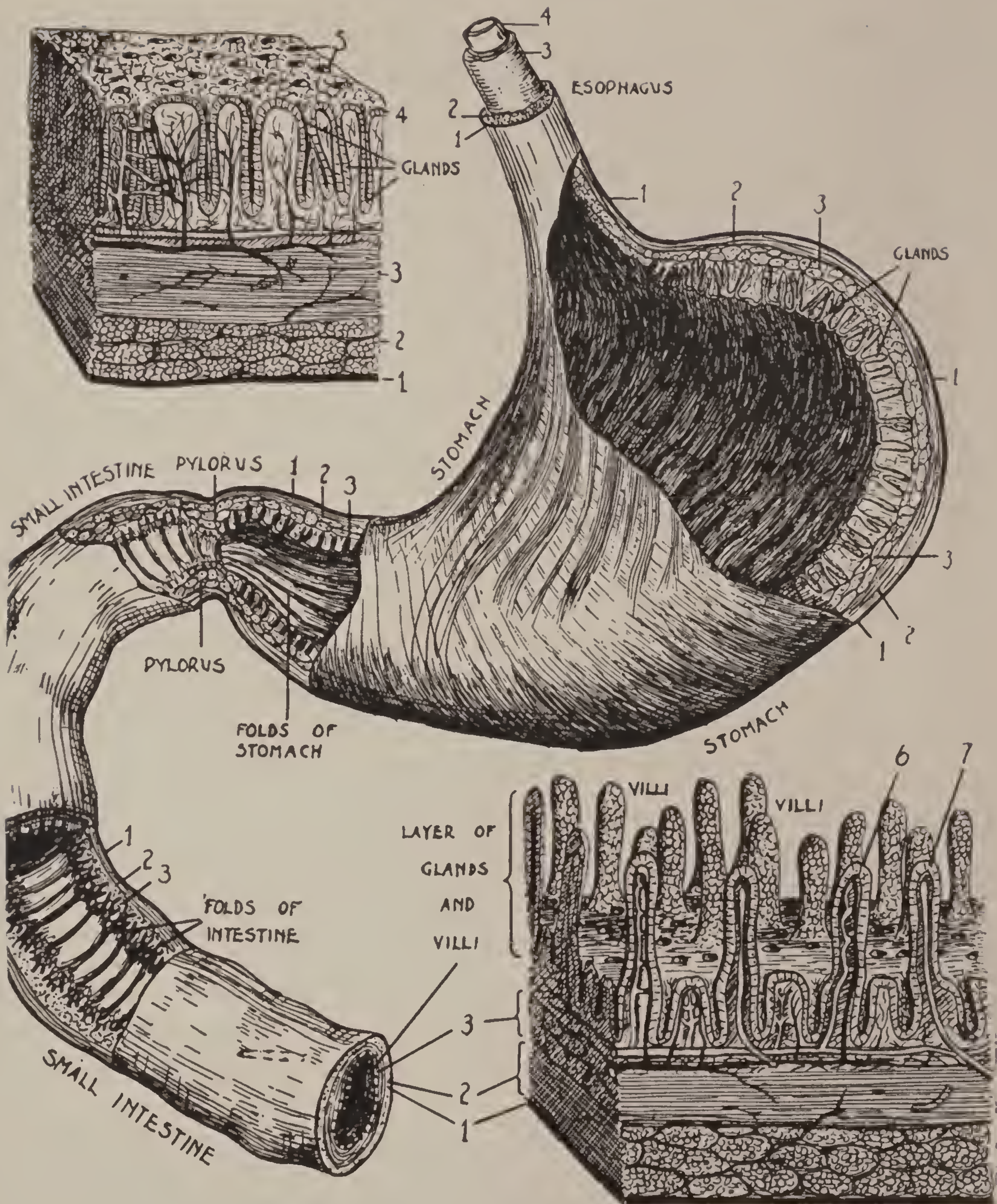

Fig. 113. A portion of the wall of the stomach, much enlarged; 1, peritoneum; 2 and 3, muscle layers; 4, lining of stomach; 5, openings of glands.

Fig. 114. Gullet, stomach and small intestine, partly opened. Numbers same as in Fig. 113.

Fig. 115. A portion of the wall of the small intestine, more enlarged than Fig. 113; 6, villus containing blood capillaries; 7, villus containing lymph capillaries; other numbers as in Fig. 113.

peritoneum; this also covers the inner walls of the whole abdominal cavity. Its work is to keep the surface moist so as to prevent friction when these organs rub against one another.

Other Structures in the Stomach and the Small Intestine.—The gullet has a very simple structure, its function being merely to carry food to the stomach from the mouth and throat. It possesses the muscle layers and a smooth lining and covering.

The stomach churns and mixes the food and passes it on to the small intestine. But it does more than this; it adds to the food a fluid to help in digestion. In the walls of the stomach are pockets or pits, as shown in Fig. 113, called **gastric glands.** These manufacture the digestive fluid called **gastric juice.** In the small intestine are similar glands extending back into the walls; these are the **intestinal glands,** producing **intestinal juice.** They correspond in structure to the gastric glands of the stomach. But in addition to these depressions in the small intestine there are finger-like outpushings of the mucous membrane called **villi** (singular villus). That is, whereas the glands lead down from the surface into the wall, the villi reach out into the hollow of the intestine. Carefully study Figs. 114 and 115 in this connection. The large intestine does not have villi.

The stomach and the intestine are also more folded or wrinkled on the inner surface than the gullet (Fig. 114). These **folds** serve to increase the surface and thus give more room for glands or for glands and villi.

There are, then, very many tiny glands in the wall of the stomach and numerous similar glands in the walls of the small intestine. But all of these are not sufficient to produce enough juice to digest all of the food. Behind and below the stomach is a long finger-like gland, the **pancreas,** that produces **pancreatic juice,** the most important digestive juice.

The juice from this gland is gathered into a tube, the **pancreatic duct,** that leads to the intestine, as shown in Fig. 116. Just before entering the intestine the pancreatic duct joins a duct (the bile duct) which carries **bile** from the **liver**. Bile is a juice produced in the liver; it can be stored when not needed at once, in a bag, the **gall-bladder** (Fig. 116).

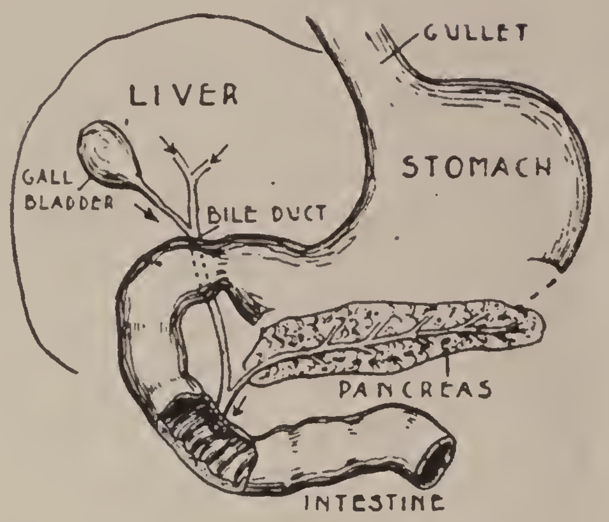

Fig 116. Some of the important digestive organs of the abdomen.

Summary and review of the chemical action of the digestive juices to show what juices digest the various foodstuffs and where:

Juice.	Produced in	Emptied Into.	Digests.
Saliva.	Salivary Glands.	Mouth.	***Starch.
*Gastric.	Gastric Glands.	Stomach.	***Proteids.
Intestinal.	Intestinal Glands	Small Intestines.	Cane Sugar.
Pancreatic.	Pancreas.	Small Intestines.	***Starch. ***Proteids. ***Fats.
**Bile.	Liver.	Small Intestines.	None.

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*Gastric juice also contains an acid (hydrochloric acid) which helps to destroy germs that get into the stomach. The acid also aids in digestion. Gastric juice will also curdle milk.

**Bile is not strictly a digestive juice; but it furnishes conditions favorable for the other juices to act, and so indirectly aids in digestion.

***See Chapter XXII for digestion of starch, proteids and fats.

Summary.

The alimentary canal is a long tube beginning at the mouth and including the throat, the gullet, the stomach and the small and the large intestines. The tube is lined with mucous membrane and covered with a thin tissue kept moist and smooth so as to reduce friction. The wall of the canal is made mainly of muscles to mix the food with the juices and to move it along. In the walls of the stomach and the intestine are many glands; other glands (salivary, pancreas and liver) are outside the canal but pour their juices into it through ducts.

The small intestine is the most important organ for chemical digestion. It is the only organ in which sugar and fats are digested, and in it the digestion of the proteids and starch is completed. Where is the digestion of proteid begun? Of starch?

Questions.

1. Mention the parts of the alimentary canal numbered in Fig. 105. 2. With a spool before you, draw a cross section and a longitudinal section of a spool. 3. Do the same for a top. 4. Sketch cross sections of the gullet, the stomach and the small intestine. 5. What is the use of the muscle layers of the alimentary canal? 6. How is this use illustrated in Fig. 112? 7. Describe the pylorus. 8. Draw a longitudinal section through the pylorus (Fig. 114). 9. Where is the mucous membrane found? 10. The peritoneum? 11. Locate the gastric glands. 12. With page 156 before you, compare these glands with the intestinal glands. 13. Where are the villi found? 14. From what part of Fig. 114 is Fig. 113 supposed to be taken? Fig. 115? 15. In what organs is starch acted on? Proteids? 16. What is the only juice that can digest fats? 17. What foods are digested in the intestine? 18. Where is the chemical digestion of proteids begun? Of starch? Of fats? Of cane sugar?

CHAPTER XXV.

The Digestive Glands.

Definition of a Gland.—You know by this time at least what a gland **does**; that is, it produces or "secretes" a fluid or a juice. You can make a list of at least four digestive juices and tell by what glands they are secreted. The mouth is always moist because the salivary glands secrete saliva and pour it into the mouth. There are many different kinds of glands in the body besides those already mentioned. The tear glands might be mentioned. They keep the eyes moist, and when you cry the eyes run over with the fluid from the tear glands.

How the Gland Cells Are Arranged.—Let us point out the kinds of cells that glands are composed of and how these cells are arranged. Gland cells are epithelial (E, Fig. 117), that is, they are arranged side by side so as to make a layer, as shown in the diagrams in the figure. This layer has one surface lying against the connective tissue, in which there is a rich supply of blood vessels. Where these come close to the gland cells they are thin-walled so that the substances may readily be taken out of the blood by the cells. These substances are changed into juices which ooze through the cells and are given off on the free side of the epithelial layer. Diagram 1 of Fig. 117 represents the glandular layer as flat. An example of such a layer is the peritoneum (1, Fig. 114), already referred to as secreting a lubricant for the abdominal organs. A gland of this kind, if extended, takes up a great deal of space, therefore, most glands have the secreting surface pushed down into

pockets and tubes as figured in longitudinal sections in diagrams 3-7, Fig. 117. Blood vessels surround these glands and come close to the gland cells; the hollow of the gland serves to catch the secreted fluid and to give it off at the opening, the mouth of the gland (M). The relation of blood vessels and gland cells is again shown in Fig. 118. Just such glands are

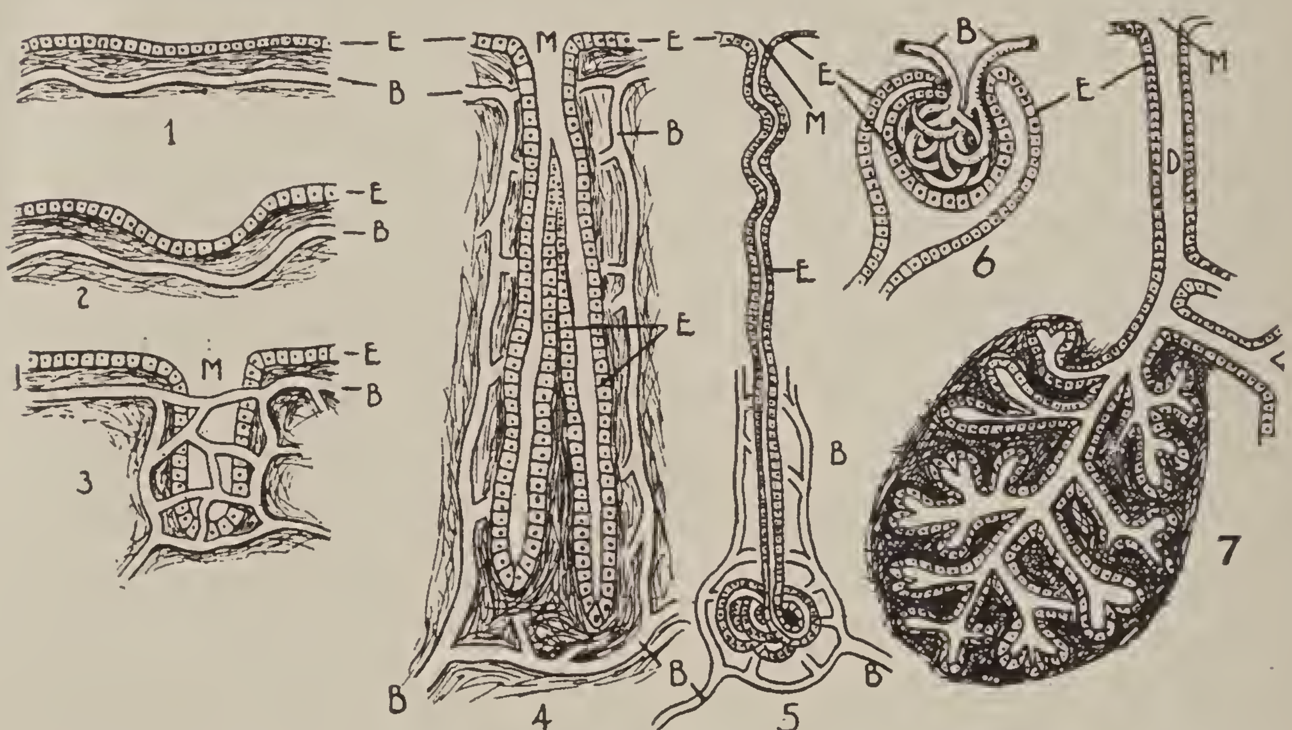


Fig. 117.—Diagrams of various types of glands. E, epithelial layer made up of the gland cells; B, blood capillaries; M, mouth of gland; D, duct. 1, gland with flat epithelial layer; 2 and 3, pocket-shaped glands; 4 and 5, tubular glands, the one at 5 having tube so long as to necessitate its being coiled up at the lower end; 6, gland with blood vessels coiled up inside of epithelial layer; 7, compound gland with many pockets and ducts.

found in the walls of the stomach and the intestine. They may be simple, as shown in Fig. 118, or compound, that is, with several branches, as in diagram 4, Fig. 117. Their exact position is seen in Fig. 114, where the wall of the stomach is represented as cut away, exposing a section of the wall. These glands are very small, much smaller than shown in Fig. 114, which has the stomach about one-fourth natural size, but shows

the glands enlarged five or more times. Fig. 113 represents a block of the stomach wall more enlarged; it shows how numerous are the gastric glands in the stomach.

The intestinal glands are similar, usually simple, like the gastric gland, shown in Fig. 118. Study them also in Fig. 115. Among the glands are projections, the villi, which project out from the walls while the glands extend down into them. The duty of the villi we shall study below.

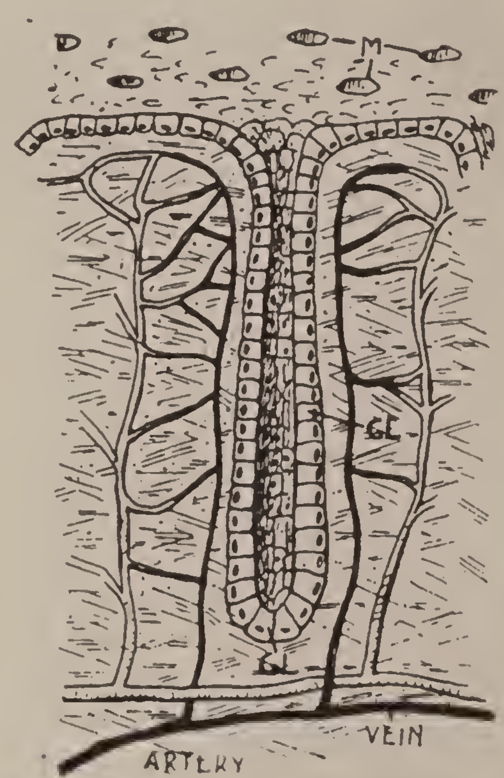


Fig. 118.—A gastric gland from Fig. 113, highly magnified. GL, gland cells; M, mouths of other glands.

Other Glands.—The glands just described occupy all of the space possible in the stomach and the intestine, but as they are not sufficient to supply the alimentary canal with all of the digestive juices needed, there are other glands of large size outside the canal but communicating with it by **ducts** or tubes to carry the juice from the gland to the proper organ. As already noted, these glands are: six salivary glands emptying their secretion into the mouth, the liver and the pancreas both opening into the small intestine. The three salivary glands on the left side are named and located in Fig. 107, which also shows the ducts and their place of opening into the mouth. The largest pair, the parotid, situated below and in front of the ear, becomes swollen when one has the mumps.

Describe the location of the pancreas; of the liver. The liver, salivary glands and pancreas are very complex organs,

not simple glands, as are the gastric glands, for example. These may have several branches at most; but glands like the pancreas have many branches and parts, as indicated in Fig. 119. Here it is seen that the gland really consists of many parts or pockets, each one of which is like a gastric or an intestinal gland. Compare 8 and B, Fig. 119, with Fig. 118.

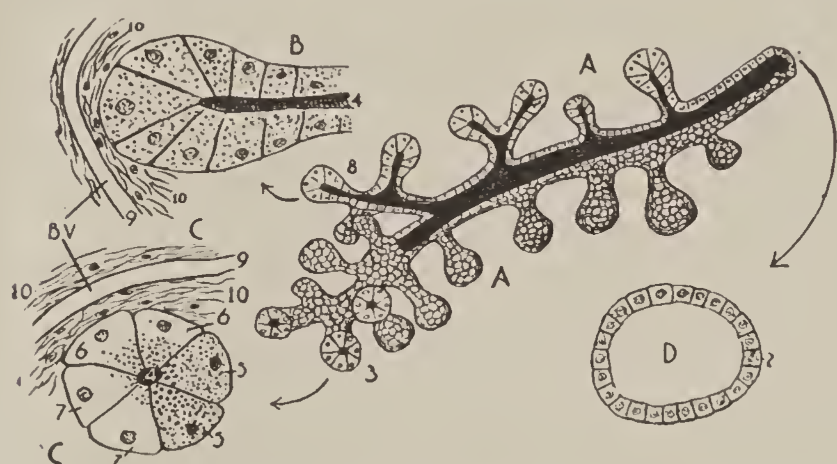


Fig. 119.—Details of tiny portion of pancreas. A, a number of pockets that empty their juice into duct (partly cut open); 8, a pocket in longitudinal section, more highly magnified at B; 3, a pocket in section, more highly magnified at C; 4, small duct; BV, blood vessel; 5, appearance of gland cells before a meal; 7, after a meal.

From the part 8, Fig. 119, the juice is poured into tiny ducts, and from these into larger and larger ones (1, Fig. 119), and finally by a large duct (Fig. 116) into the intestine. B and C (Fig. 119) show the working cells of the gland, and it is readily seen that these are epithelial cells (compare with Fig. 117. After the manner of all glands they get material from the blood (BV) wherewith to make their secretion.

Summary.

There are many different kinds of glands in the body, but they all agree in having the cells that do the work arranged as an epithelial tissue which lies upon connective tissue very rich in blood. The cells secrete fluids, that is, take out of the blood materials and make them over into various fluids. The digestive glands are of five kinds: (1) the gas-

tric glands in the walls of the stomach; (2) the intestinal glands in the walls of the intestine—these are very simple and numerous. Outside the alimentary canal, but communicating with it, are: (3) six salivary glands, (4) the pancreas and (5) the liver.

Questions.

1. What kind of tissue contains the working cells of a gland? 2. What letter marks the layer of gland cells in Fig. 117? 3. Where do the cells get the material from which to make their juices? 4. Which gland can secrete the more juice: C or D of Fig. 117? 5. Which has more gland cells? 6. Describe a gastric gland. 7. Where are glands like this shown in Fig. 113? 8. Locate them also in Fig. 114. 9. Compare the glands of Fig. 115 with the gastric glands. 10. What part of Fig. 119 is like a gastric gland? 11. Why does the blood have to come near the working cells of a gland? 12. Where are the gland cells of Fig. 118? Of Fig. 119?

CHAPTER XXVI.

How the Food Is Taken Up by the Blood: Absorption

Digestion has been defined as the process of making the insoluble food soluble. Even after this has been accomplished, if the food remains within the alimentary canal, it does the body absolutely no good. What use can it be to the cells of hand or head or foot? To be of use to any part of the body it must be carried to that part. How is it carried from the food canal to all parts of the body? You will at once answer, by the blood. **The blood is the carrying agent of the body.** Bear this clearly in mind: the blood carries food to the cells and waste matter away from them. What we have to consider now is how the food gets into the blood, or, in other words, how the blood **absorbs** the food.

Where the Food Is Absorbed.—What foodstuffs are absorbed from the stomach; that is, what foodstuffs have been partly digested in the mouth or the stomach? In the intestine digestion of all foods is completed.

Fig. 120 represents a small part of the wall of the stomach, highly magnified, several glands being shown. What is the work of the cells at B? What is the function of the blood vessels running to these cells? What is the function of the cells at A? These cells at A, it is to be noted, touch the food inside the stomach. These are absorptive cells, taking up salts and digested starch and proteids and passing them on to the blood vessels just underneath them. Compare with Figs. 113 and 118.

When we look at the inner surface of the small intestine we

find it like the stomach in that it is in folds, but it differs in its soft, velvety appearance. If somewhat enlarged, the velvety surface comes to look more like the rough surface of a good coarse bath towel. This is due to the presence of tiny projections, the **villi**. Between the villi are the intestinal glands. Fig. 115 shows glands and villi in surface view and in section.

The function of the villi is to absorb the digested food. This will be better understood from a study of Fig. 121. The villi are represented in section at 1, and the glands at 2. What is the function of the cells at A? of those at B? What advantage has the small intestine over the stomach in the way of absorbing food? Note that the cells at B of these figures take substances out of the blood (gland cells), while those at A pass food substances into the blood. Since most of the food is digested in the intestine it is also here largely absorbed. This requires a very large surface. There are three ways by which the surface of the small intestine is increased: (1) by the great length of the intestine; (2) by the folds of the inner layers (Fig. 114); (3) by the villi, as just discussed. The folds are covered with innumerable villi.

FIG. 120.

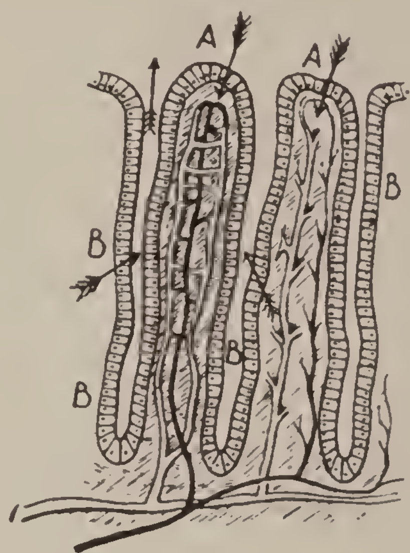


FIG 121.

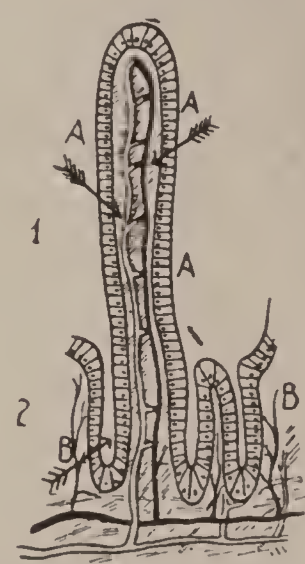


Fig. 120.—Diagram of portion of wall of stomach, showing three gastric glands; A, absorbing cells; B, gland cells.
Fig. 121.—Diagram of portion of wall of intestine, showing a villus (1) and three intestinal glands (2). Other features as in Fig. 120.

The villi are important absorptive organs. Fig. 122 is a diagram showing three villi. Note the mucous membrane covering. (M). It is through this that the food must pass. Ready to receive the food that passes in are (1) blood capillaries (fine blood vessels), and (2) lymph capillaries, called **lacteals.** These divide the work of carrying off the food: the blood capillaries take up the digested proteids and carbohydrates, and the lacteals, the fats. All blood and lymph finally reach the heart, but by different routes. The carbohydrates and proteids pass by the portal vein to the liver and thence to the large vein running into the heart from below; the fats pass through the lymph glands, thence by the great thoracic duct into a large vein running towards the heart from above. (See Fig. 124.)

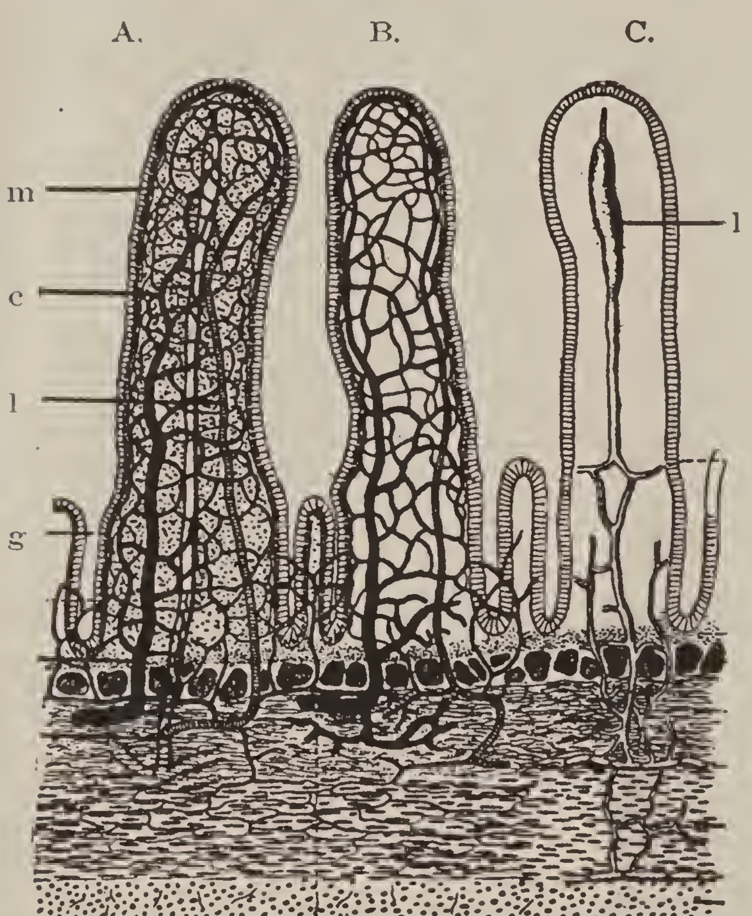


Fig. 122.—Three villi of the intestine: A. with blood capillaries (c) and lacteal (l); B, with blood capillaries only; C, with lacteal (l) only; g, intestinal gland.

Osmosis.—Consult Fig. 121 again. Note that the food must pass through a membrane to get into the blood; also through the walls of the blood vessels. We say it does this by **osmosis,** by which we mean that it oozes or soaks through a thin, moist membrane. Some substances pass through a membrane easily, as, for instance, water or salt solution. Other

substances, like gelatine or the white of an egg, do not osmose to any extent. These must therefore be digested before they can be absorbed into the blood by the process of osmosis.

Experiment to Illustrate Osmosis.—Take an egg, a glass tube or a straw about a foot long, a bottle to hold the egg and a vessel to hold the bottle and the egg, as shown in the accompanying figure. With great care crack the shell at the large end of the egg. and pick off the bits of shell with the finger nail, being careful not to injure the membrane under the shell. Now, punch a hole in the other end of the egg, and into this stick a straw as far as the center of the yolk of the egg. With melted beeswax or paraffin or tallow seal the joint of the straw to the egg. Set up the apparatus, as in Fig. 123, and add water, immersing half of the egg, and await results. If the membrane of the egg is not broken where it touches the water, the water will pass into the egg faster than the contents of the egg will pass out. This causes the contents of the egg to rise in the tube. Watch the experiment and explain what you see.

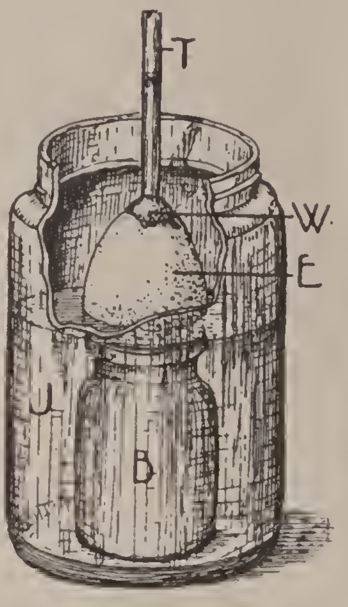


Fig. 123.—Experiment in osmosis. B, bottle; J, jar; both containing water; E, egg; T, glass tube or straw sealed to egg with wax (W).

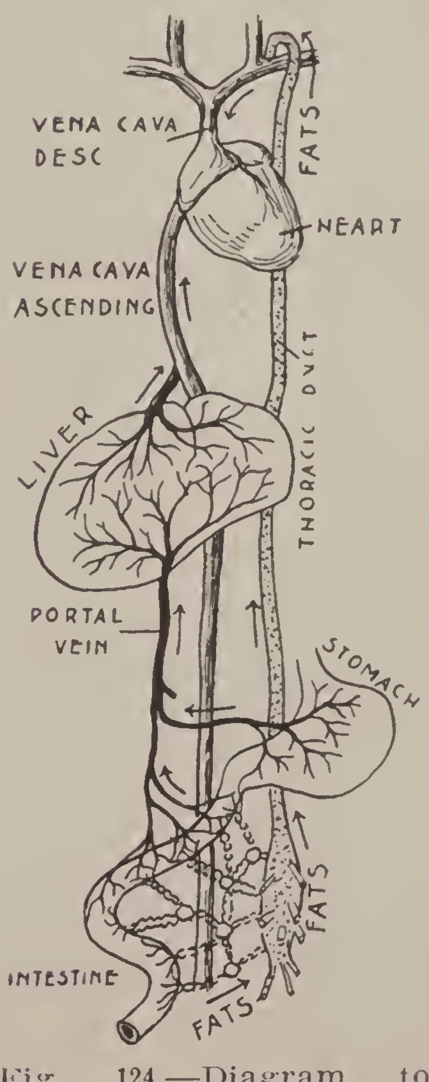


Fig. 124.—Diagram to show the course of foodstuffs to the heart.

Summary.

After the food is digested it is worthless unless absorbed by the blood

and carried to the hungry cells of the body. The digested or liquid food is absorbed through the thin mucous membrane of the stomach and the small intestine, especially of the latter; for, projecting out of the wall of the small intestine, are thousands of villi containing blood and lymph capillaries that take up the food and carry it by the veins to the pumping station, the heart.

Questions.

1. Why must food get into the blood? 2. How does the food pass in? 3. Why must food be soluble to be absorbed by the blood? 4. What membranes must the food pass through to get into the blood? (Fig. 120 and 121.) 5. Describe an experiment to illustrate osmosis. 6. Describe a villus. 7. What membrane in Fig. 121 corresponds to the membrane around the egg in Fig. 123? 8. What organ in a villus takes up fats? 9. Proteids and carbohydrates? 10. What foodstuffs pass through the liver before going to the heart? 11. What cells in Fig. 121 are touched by the nearly liquid contents of the intestine?

CHAPTER XXVII.

The Making of Living Substance: Assimilation.

We have thus discussed in the last few chapters: (1) kinds of food that are eaten; (2) how these foods are digested, or prepared for absorption; (3) how they are absorbed or taken into the blood to be pumped by the heart to all of the cells of the body. We will now consider how the food passes out of the blood to supply the cells of the body.

Blood as the Carrier.—It may be said that the food gets out of the blood after it has reached the hungry working cells in a distant part of the body in the same way as it gets in at the villi—by osmosis. The blood absorbs food through the cells covering the villi. For this purpose the blood capillaries come close under the mucous membrane cells covering the villi (Fig. 122), through which the food is absorbed. By osmosis the food enters the blood. Let us now see that the blood capillaries pass the food on to the other working cells of the body, just as the cells of the villi pass it on to the capillaries. Fig. 125 shows the blood tubes or vessels lying close to the cells of the body. These might represent any cells, as of the head, foot or finger. The blood vessels leading toward the cells of an organ of the body are called **arteries**; they branch and grow smaller and smaller the further they are from the heart. After they have become very small and thin-walled, they are called **capillaries.** Through these capillaries the blood flows into **veins,** which carry the blood back to the heart to start over again on its round or circulation. As the blood passes through

the capillaries it comes close to the cells of the body. Note that it does not touch the cells, but stays in the blood vessels—it merely passes close enough to the cells so that, by osmosis, the food may pass to the cells, just as water passes into the egg through the egg membrane in the experiment described above. Fig. 125 also shows another condition that deserves special notice: the cells of the body are surrounded by a thin, colorless fluid called **lymph.** It may be said that we, that is our cells, live in a fluid just as fish live in water. You will note by studying the diagram that substances which pass from the blood to the cells must first pass through the lymph that fills all of the spaces among the cells.

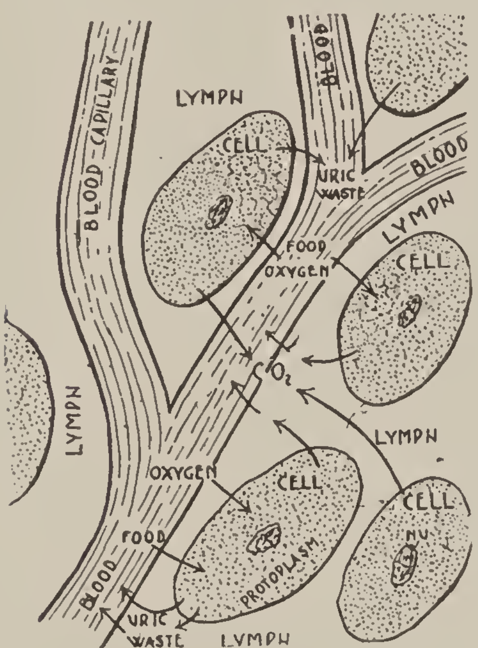


Fig. 125.—Diagram to illustrate the relation of cells, lymph and blood. CO — carbon dioxide.

Assimilation.—The question now is: What becomes of the food after it reaches the cell? This is the climax of the subject—the food becomes in part living substance. This is called **assimilation** (Latin **ad,** to and **similis,** like). Only living substance is able to do this—to make dead matter over into living matter like itself. This living matter, found in all living cells, is called **protoplasm.** A cell has therefore been defined as a mass of protoplasm, containing a nucleus (Fig. 83). In doing work a cell uses up some of its protoplasm, but it creates new protoplasm out of food brought to it—**it repairs itself.** No machine can do this as can the living body.

Growth of Cells.—It is easy to see from this how cells grow and multiply. As the body grows more cells are developed

from those already there. The cell grows until it becomes "full size," when it splits in two (Fig. 126); then there are two cells to grow again to full size and to multiply as before. When the skin is injured it grows back from around the edge of the wound, for the skin is formed only from skin cells already present. The material for growth is furnished by the blood under and in the skin. Assimilation, growth and multiplication are processes that are performed only by protoplasm or living substance contained in the cells of animals and plants.

Wastes.—In burning or oxidizing the tissues and food in the body, waste substances are produced by the cell. The chief waste substances* are carbon dioxide and uric waste. These are harmful to the cells and must be carried away by the blood. So without end, from birth till death, protoplasm is built up out of food and torn down by oxidation (burned) that life may go on. It is truly "life by death."

Fig. 126.—Cell growth and division.

Food Storage.—But some substances can be stored in the body, to be used in case of need, when food cannot be eaten or secured. How long can a person live without eating? A kind of starch (liver starch) is prepared by the liver and stored in the liver and muscles. Other foodstuffs are made

*Here are not included the indigestible wastes passed from the small intestine into the large intestine. These wastes are not produced by the cells of the body, never having been absorbed by the villi.

into fat by the cells of the body and stored in certain cells. These cells grow larger and larger until filled with large drops of fat, as shown in Fig. 127.

Fig. 127.—Growth of a fat cell by the accumulation of drops of oil.

How Disease Germs Feed in the Body.—Sometimes some of the food that is digested in the alimentary canal and made ready for absorption goes to support foreign plants and animals called **parasites,** that get into the blood accidentally. Such a parasite is the tapeworm, which lives in the intestine. It has no eyes, limbs, mouth or digestive organ of any kind—it simply lies in the food substance in the intestine and soaks up the food through the walls of its body by osmosis, just as a cell of the body does. The person or animal in which the tapeworm lives does the work of digestion for it. Besides large parasites like tapeworms, hookworms, etc., there are millions of disease germs that sometimes live in the body. These and their harmful effects have already been described.

A moment's reflection will show you why it is that parasites often thrive in our bodies. There are three things living beings need in order to live: food, water and oxygen. In the body parasites find these things: (1) food in the mouth, mucous membrane, the stomach and intestine, the blood and the cells; (2) water, for seventy-five per cent of the body is water; (3) oxygen is constantly being carried from the lungs to the tissues. Most parasites also need warmth and this we also furnish, for our bodies are always at a uni-

form temperature of 98.6 degrees Fahrenheit. No wonder that many kinds of bacteria and other parasites make our bodies their home, for we take so good care of them.

This can be made plain by Fig. 128. Suppose we take a bacterium living in the blood. From the blood it takes food and oxygen and water, and into the blood it pours its waste substances. With the waste substance it gives off poisons called **toxins** (page 5), which cause disease by destroying our own cells. Then our cells go to work producing **antitoxin** (Fig. 128) to destroy the toxin, thus often protecting us against the harmful effects of disease germs.

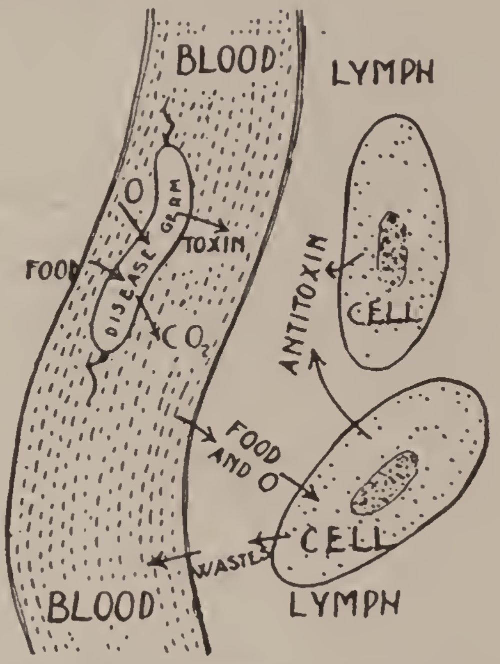


Fig. 128.—Diagram to show how a disease germ lives in the blood, taking up food and oxygen (O) and giving off wastes and toxins.

Summary.

The most wonderful substance in the world is protoplasm, the living substance of which the cells of our bodies are composed. The most wonderful thing this protoplasm can do is to change the food we eat into substance like itself. This process is called assimilation. The cells of the body are surrounded by lymph. Food passes by osmosis out of the blood capillaries into the lymph and then into the cells, and waste matter passes back into the blood. Disease germs feed in the body just as the cells of the body themselves do.

Questions.

1. What is the chief work of the blood? 2. Define arteries, capillaries and veins. 3. In which of these does the blood take on and give off its loads? 4. Why do the capillary walls have to be thin? 5. Does the blood touch all of the cells of the body? 6. What is the use of lymph and where is it found? 7. What is assimilation? 8. What is the most wonderful work of protoplasm? 9. Where is protoplasm found? 10. How are waste substances produced? 11. What are the chief wastes made by protoplasm? 12. Why do the cells have to tear down after building up? 13. How do wastes get into the blood? 14. What does the blood do with them? 15. Draw Fig. 125 on the board and discuss the work of cells. 16. Show how disease germs feed in the body just as the body's own cells do. 17. How do germs harm the body? 18. What is produced by the cells of the body to counteract the germs of disease?

CHAPTER XXVIII.

Why We Breathe.

Review.—In the previous chapters it was pointed out that the cells of the body are continuously in need of food and that this food is needed by the cells for growth and repair, and to keep them warm and to enable them to work. It was also shown that it is not the food itself that produces heat, but the burning of the food, or the burning of cell substance itself, that causes us to be warm and enables us to move. We might compare the body to a stove. The stove is not heated merely by laying the wood into it, but by the burning of the wood. To burn the wood, a draft into the stove is necessary; cut off the draft and the fire goes out. This simply means that oxygen from the air is needed to combine with the wood to produce heat. The same is true of the body. What the draft is to the stove the breath is to the body. Oxygen is needed by the cells to burn up the food and to keep up the activities of life; stop breathing, and the body dies and grows cold.

In the present chapter we shall see how the cold, dust-laden air containing the oxygen we need, becomes warmed and cleaned as it passes through the nose, the voice-box and the wind pipe into the lungs; how, after reaching the lungs, the oxygen gets very close to the blood, and how it is absorbed by the blood so as to be carried where it can be of use to the cells of the body.

How Carbon Dioxide (CO_2) Is Produced.—You have learned that plants, in the making of starch, used up the CO_2 from the air and gave off oxygen into it, thus purifying the air

for men and animals. You learned, too, that starch and other foodstuffs contain carbon, and that when burned in the body the carbon combines with the oxygen to form CO_2. This is waste matter and must be given off by the cells into the lymph and blood, and carried away to be thrown off from the body in the breath, just as the waste products from burning of wood in the stove or furnace are given off into the stovepipe or chimney as smoke and gas.

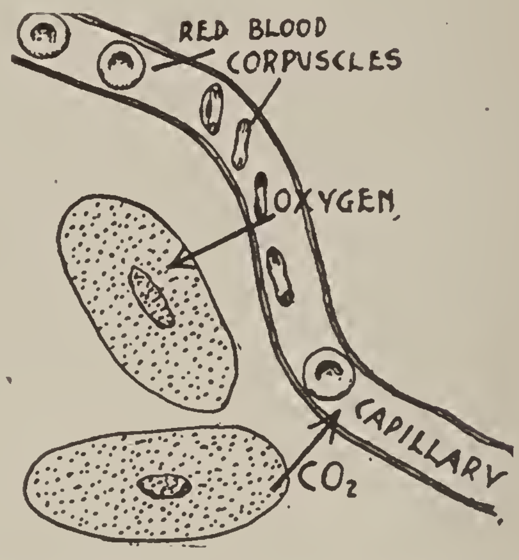


Fig. 129.—Diagram illustrating respiration of the cell of the body. CO —carbon dioxide.

Respiration Defined.—This process of taking up oxygen and giving off CO_2 is called respiration; or, in other words, respiration is the exchange of CO_2 for oxygen. Every cell does this (see Fig. 129); therefore every cell respires. But the cells are so far from the outside world, that the blood must carry oxygen to the cells and CO_2 away from them. In the earthworm the exchange of gases between the blood and the outside air takes place through the whole skin. In the fish the gills are the organs of respiration. The gills are covered with a thin membrane and filled with blood; it is through this membrane that the fish takes oxygen out of the water and gives off CO_2 into the water. In man and the higher land animals the air containing oxygen must be taken into the lungs **(inspiration)** and breathed out again **(expiration).** While in the lungs the air gives off oxygen to the blood and takes CO_2 from it. Just how the thin membrane through which the exchange of gases takes place acts, and how the blood comes close to this thin membrane, we shall see below.

Observation and Experiments.—(1) Bring earthworms to school and place them in shallow dishes or plates with a little water. Earthworms must be kept moist, for if their skin dries they cannot breathe through it, and therefore they die. Note the red blood vessels through the skin of the animal. Why is it that fish and men cannot have skin delicate enough for oxygen to pass through? (2) Keep a goldfish, minnow or other fish in a clear glass jar of water. Where are the fish's gills? Note that the water goes into the mouth and out of the gills-slits on the side just behind the head. Boys who have "strung" fish can tell all about this. How does the fish take up oxygen dissolved in water and give off CO_2 into the water? (3) Watch your deskmate breathe; that is, inspire and expire air. Watch him when he is not aware of it and count the number of breathing movements per minute. (4) Take a short candle and light it. Invert a fruit jar over the candle and note what happens (Fig. 130). Why does the candle go out? Air contains four parts of nitrogen to one part of oxygen. But not all of the oxygen can be burned out of the air with a candle, for the candle goes out before all of the oxygen is gone. (5) To show more plainly that some of the oxygen disappears, burn a match head under a quart jar, with the jar inverted over water, as shown in Fig. 131. To do this the match must stand upright and be surrounded by an inch of two of water in a broad vessel. The match can be stuck into a square block of potato to hold it up. Now, with another match light the match that is to burn out the oxygen from the jar. As soon as the match begins to burn, quickly place the jar over it and into the water. Watch the water rise in

Fig. 130.—A candle will go out for lack of oxygen if covered with a jar.

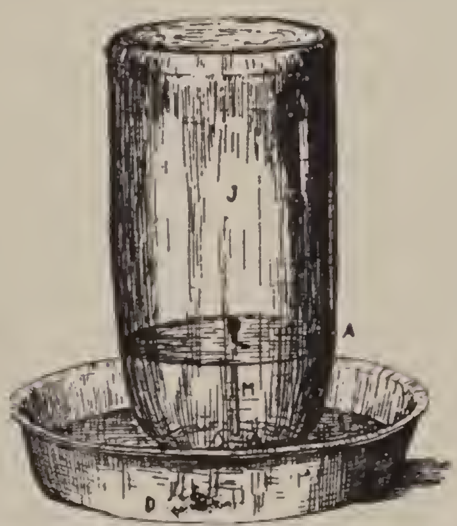


Fig. 131.—Burning the oxygen out of a jar (J) of air; M, match stuck into a piece of potato in a dish (D) of water. A, level of water after removal of oxygen by burning of match-head.

the jar. The oxygen has been used up out of the air in the jar, and the water has taken its place (Fig. 131). (6) That expired air contains large amounts of CO_2 can be demonstrated easily. Dissolve a little fresh lime (such as masons use to make mortar) in some water and either filter it to get it clear, or allow it to stand covered until the undissolved particles settle to the bottom; then pour off the perfectly clear liquid on top. Now, with a straw or a glass tube blow your breath through this clear liquid (Fig. 132). The milky condition of the liquid indicates that CO_2 has been added to it.

Summary.

Fig. 132.—Clear lime-water will become milky from carbon dioxide in expired air.

Respiration is the exchange of CO_2 for oxygen. The oxygen is taken from the air, and is used in the body for oxidation. The oxygen unites with the carbon of our food and tissues, producing CO_2, a waste substance, injurious to the body. Every cell of the body uses oxygen and gives off CO_2. The blood carries the oxygen to the cell and the CO_2 away from it. The CO_2 leaves the body in the breath, as can easily be seen by experiment.

Questions.

1. Define respiration. 2. How is CO_2 formed in the body? 3. In a stove? 4. Why is oxygen needed? 5. Why do we need more oxygen when running than when sitting? 6. What common observation seems to prove this? 7. How does each cell secure oxygen and get rid of CO_2 (Figs. 125 and 129)? 8. How does the whole body get rid of CO_2 and take on oxygen? 9. How can you prove that about one-fifth of air is oxygen? 10. How can you show that CO_2 is given off in the breath?

CHAPTER XXIX.

The Breathing Organs.

The breathing organs, or the organs of respiration, are the lungs, the air passages carrying the air to and from the lungs, the bones of the chest and the muscles attached to them. The chest and its muscles work together in the breathing movements.

The air passages are the nasal passage leading from the nostrils back to the throat or **pharynx,** where the air passage and the food passage cross; the **larynx,** or voice box, the **trachea,** or wind pipe, the last named dividing opposite the lungs into two **bronchi,** and these, after entering the lungs, divide into smaller and smaller bronchial tubes or **bronchioles,** as the branches of a tree divide until the smallest twigs are reached. All of these are illustrated in the figures.

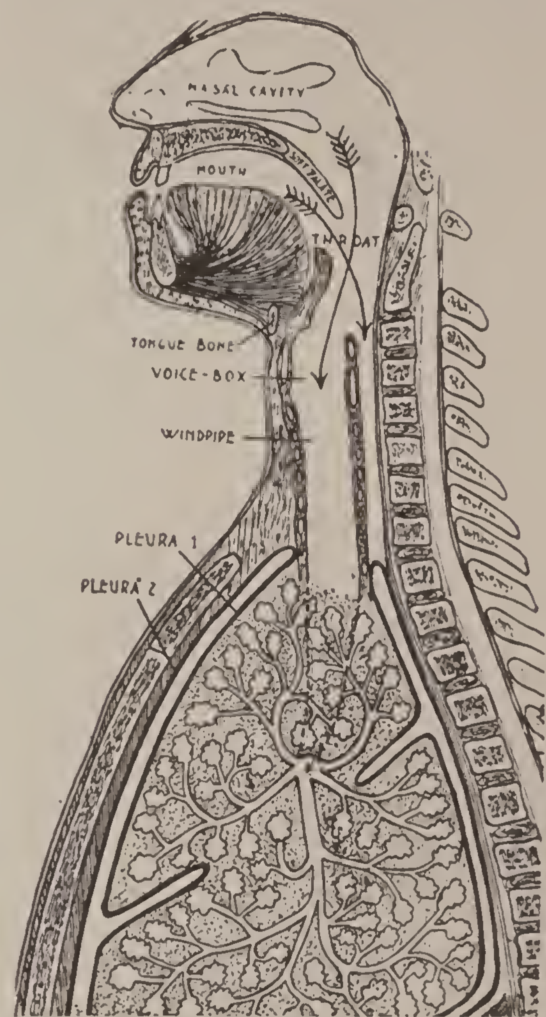


Fig. 133.—Diagram of the air passages; arrows show crossing of food and air passages in the throat. Air sacs of lungs and pleurae shown.

The nasal passages, like the mouth and throat, and other organs before mentioned, are lined with mucous membrane. Here end the nerves of smell, which can detect odors in tiny particles coming in with the

air we breathe. We say the nose is the organ of smell. The mucous membrane is, furthermore, richly supplied with blood; and as the passage is very crooked because of passing between and around the irregular bones* (Fig. 134) of the skull, the air is warmed as it passes through. The nostrils are beset with hairs so as to prevent coarse particles of dust from passing further into the air passage. Now, mention two reasons why we should breathe through the nose and not through the mouth. Very often children (and rarely grown persons) have spongy growths called **adenoids** just behind the nose (Fig. 135), thus stopping up this passage and forcing the patient to breathe through the mouth. Children who are "mouth-breathers" are not healthy, and when they attend school do not do well in their studies.

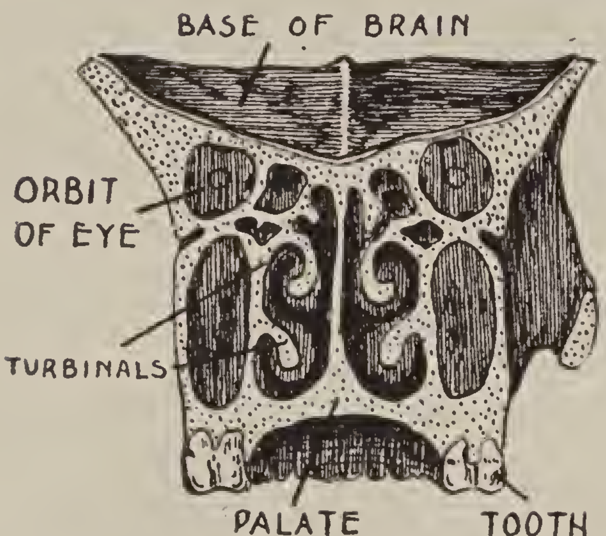


Fig. 134.—The turbinal bones, showing the irregular nasal passages.

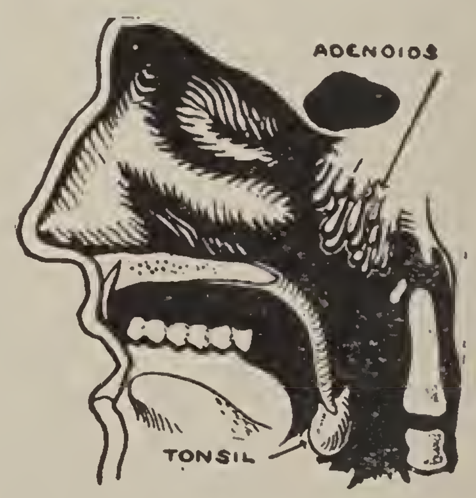


Fig. 135.—Adenoids are spongy growths in the nose that tend to stop up the nasal passages. (Compare with Fig. 133.)

The larynx or voice box leads off from the pharynx. As the air crosses in the pharynx the path taken by the food (see Fig. 133) there is danger of food as well as air going down into the larynx. To prevent

*Called the turbinals, a pair of the skull bones.

this there is a flap, the **epiglottis** (Fig. 139), that fits down over the top of the larynx during swallowing, and is raised during breathing. Point out this organ in Fig. 133. Can you raise and lower your epiglottis at will? The larynx is a "box" of cartilage tissue (called gristle by butchers) which is strong and somewhat elastic. The "Adam's apple" at your throat is the front of the larynx. Feel it and press it. Cartilage tissue, shown in Fig. 136, consists of cells with tough and elastic substance between the cells. It is another of the tissues of the body and finds a variety of uses. Name the other tissues you have studied. The larynx is made largely of cartilage so as to keep the passage always open for the air; for cartilage, while elastic, is stiff enough to support organs. The outer ears and the tip of the nose are supported by cartilage. Feel them. If the larynx were made of connective tissue instead of cartilage what would happen during inspiration?

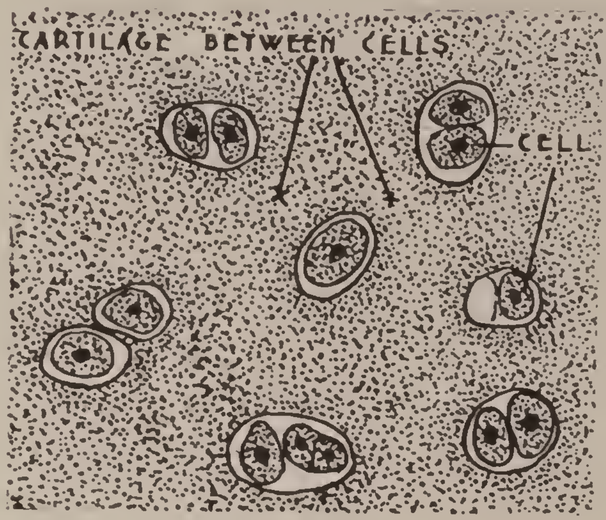


Fig. 136.—Cartilage tissue.

Experiments on the Voice.—Take a strip of paper about three-fourths of an inch wide and two inches long, or a blade of grass of that size and place it between the thumbs, as shown in Fig. 137. Now blow hard against the edge of the paper or grass. Stretched across the larynx are two flaps of connective tissue, each of which corresponds to the strip of paper you used in the experiment. (2)

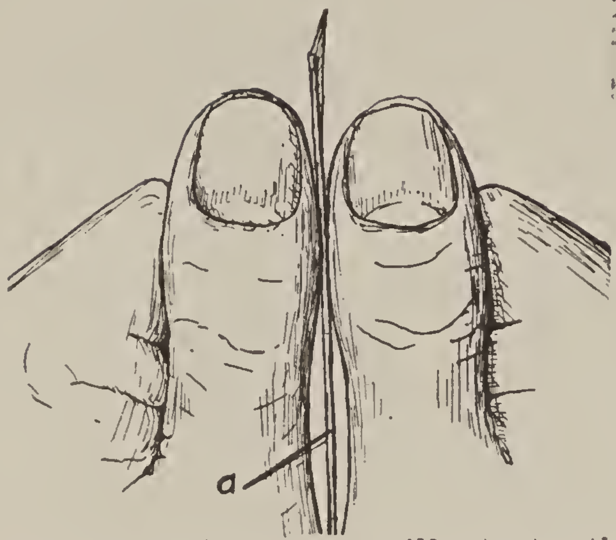


Fig. 137.—Diagram to illustrate the vibration of the vocal cords. The breath is blown upon **a**, a slip of paper between the thumbs.

To prove that the vocal cords are located in the larynx, sing a note, and as you sing, alternately press against and let go of the Adam's apple. When you whisper you do not use the vocal cords. (3) As the vocal cords produce sound the hollows of the throat, mouth and nose increase the sound. To illustrate this, hold up a tin bucket horizontally to one side of the mouth and speak into the bucket, noting the effect.

The structure of the trachea, bronchi and bronchioles is almost the same. They are held open by rings of cartilage (A and B, Fig. 139), and are lined with mucous membrane, as is also the larynx. This mucous membrane has a peculiar structure. The cells are supplied with tiny hair-like projections called cilia (Fig. 138) standing out from the membrane into the tube. These cilia are constantly in motion and act like living brushes sweeping mucus containing fine dust particles out of the lungs toward the throat, where it gathers to be coughed up.

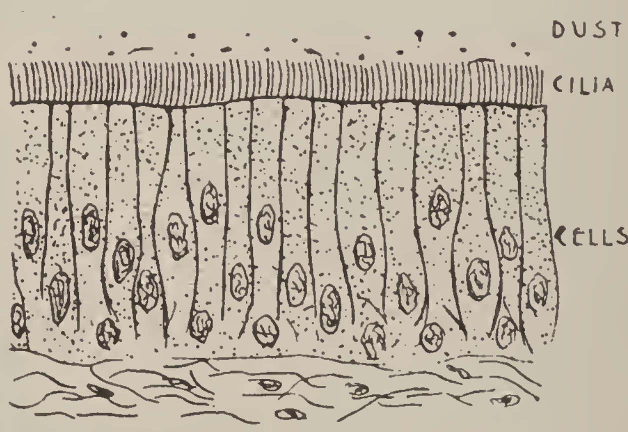


Fig. 138.—Ciliated cells of the air passages have it as their duty to sweep dust back into the throat.

What two provisions has nature, then, made to keep dust out of the lungs?

The Lungs.—Study Figs. 4 and 5 and the figures in this

chapter. How many lungs are there? What is their location with reference to the heart? How are they connected with the bronchi? In what cavity do they lie? What organ do they touch below? How are they and the heart protected from injury?

The lungs are made up largely of air tubes, air spaces and connective tissue and blood vessels. The air spaces make them light and spongy, so that they expand and contract readily with each inspiration and expiration. In their movements the lungs rub against each other, against the diaphragm, against the heart and against the walls of the thorax. To reduce friction they are covered with a double bag, two **pleurae** (singular pleura), between the two layers of which is secreted a liquid, the **pleural fluid.** One pleura thus covers the lungs, the other lines the thorax, as shown in Fig. 133. What is the function of the pleural fluid? When the pleurae become inflamed and hot, a person is said to be afflicted with **pleurisy.** Compare the pleurae with the peritoneum.

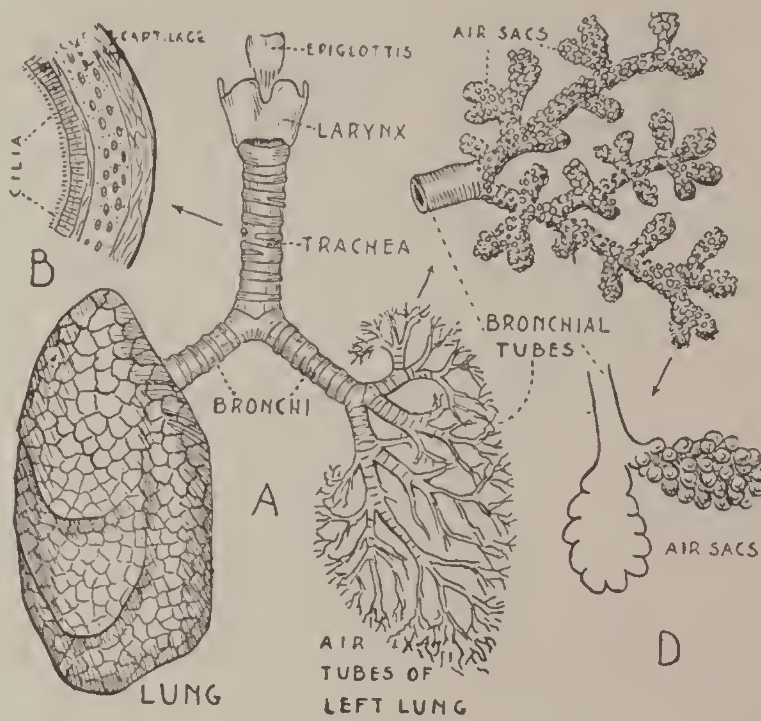


Fig. 139.—The lungs and air passages (A); B, a small part of the trachea or windpipe, magnified, showing cilia and cartilac in the wall; air sacs in upper right hand corner are a portion of A enlarged; D, the tiniest air sacs still more enlarged.

How We Breathe.—We breathe by making the cavity of

the chest alternately larger and smaller. When it is made larger there is more room for air and air comes in to fill the

FIG. 140.

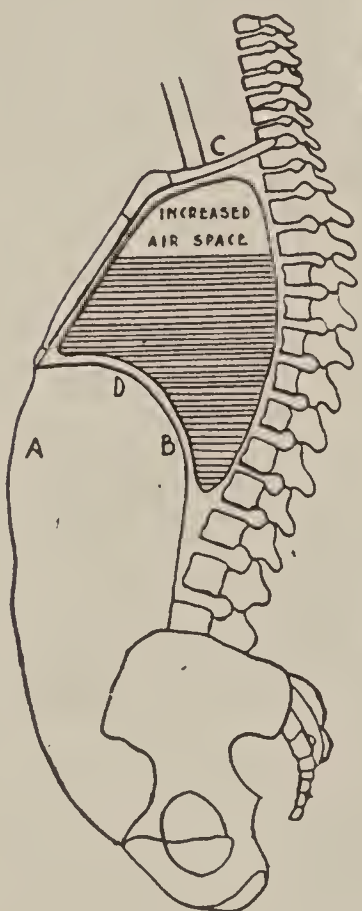


FIG. 141.

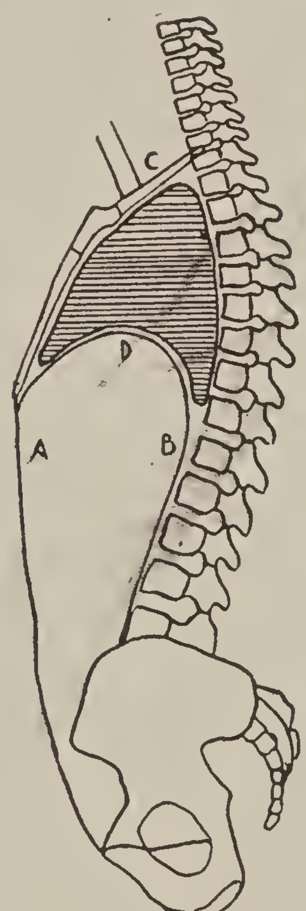


FIG. 142.

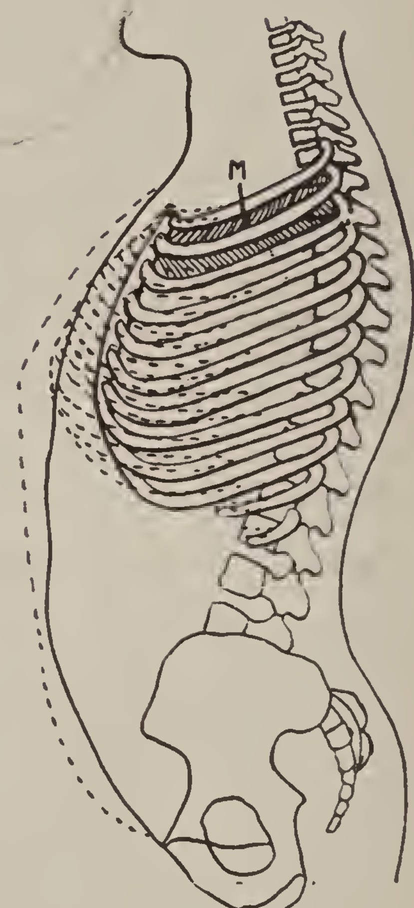


Fig. 140.—The chest and abdomen in inspiration. AB, horizontal diameter; CD, vertical diameter of chest; D, diaphragm.

Fig. 141.—The chest and abdomen in expiration.

Fig. 142.—Inspiration is partly due to the raising of the ribs. Solid lines, position of organs in expiration; dotted lines, in inspiration. Muscles between two of the ribs are shown at M.

space. The question "How we breathe" becomes "How do we make the cavity of the chest larger or smaller?" A study of Figs. 140-142 will illustrate the two ways of increasing the capacity of the chest. Comparing Fig. 140 with Fig. 141 it will be seen that by lowering the diaphragm D the diameter

C to D is increased; when it is raised, the space of the chest is decreased and air is forced out. The diaphragm is therefore one of the breathing organs. It is a flat muscle and is lowered by contraction. Measuring the diameter AB with a slip of paper in the two figures, it will be found to be greater in Fig. 140. This diameter is increased by raising the ribs. You will note that the ribs are inclined forward. At M, in Fig. 141, are shown muscles between two adjacent ribs. Such muscles exist between all of the ribs, and when they contract the ventral ends of the ribs are raised and the chest expands. The ribs and the muscles between them are also breathing organs. When the size of the chest cavity is thus increased, air rushes in because of the greater pressure from without, and the lungs thus expand. When the ribs fall or are pulled back, air is forced out of the lungs. Fig. 142 indicates the relative positions of thoracic and abdominal walls at inspiration (dotted lines), and at expiration (solid lines). The harmful effects of tight clothing about the waist or chest are readily understood from this description of how we breathe.

The Air Sacs of the Lungs.—Thus by breathing movements the air is drawn into the lungs through the air passages. The oxygen finally diffuses down into the finest air tubes. (Fig. 139.) At the ends of these there are air spaces or air sacs surrounded with extremely thin membrane (see lower part of Fig. 133 and also C and D, Fig. 139). Around the air sacs, very close to this thin membrane, are many bood capillaries. Just as the food passes through the villi of the small intestine into the blood by osmosis, so in the lungs oxygen passes from the air sacs of the lungs into the surrounding blood capillaries and CO_2 passes from the blood vessels into the air sacs, as indicated in Fig. 143. At the cells the exchange of

oxygen for CO_2 again takes place, as discussed on page 186, and again shown in the diagram, Fig. 145. The intimate relation of blood vessels and air sacs is shown in Fig. 144.

In **pneumonia**, the disease germs cause an inflammation of the lining of the air sacs. In **asthma** the smaller bronchial tubes become partially stopped up, rendering it difficult for

FIG. 143. FIG. 144. FIG. 145.

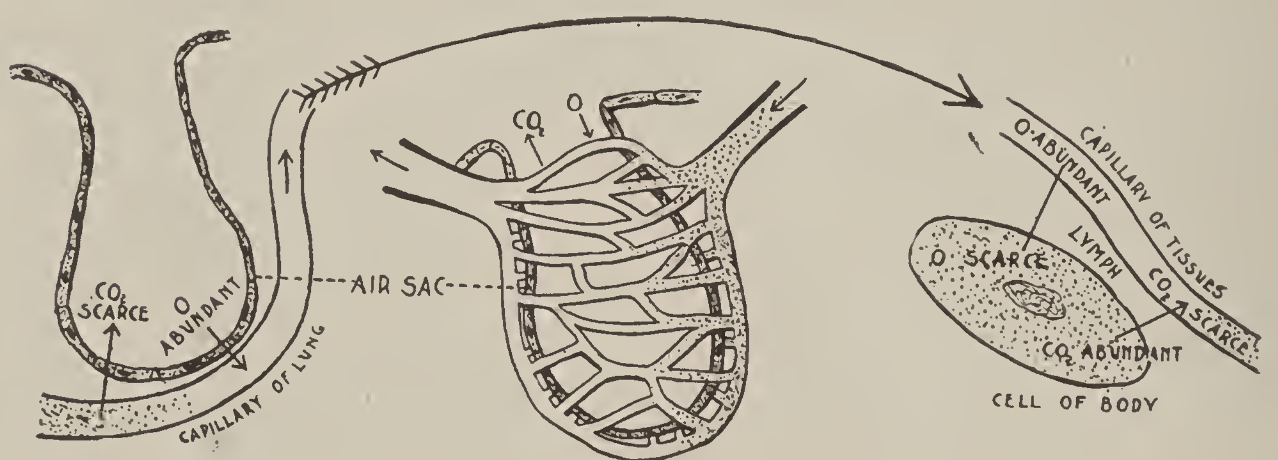


Fig. 143.—Diagram illustrating respiration in the air sac of the lung. CO_2—carbon dioxide; O—oxygen.
Fig. 145.—Diagram illustrating respiration of a cell at a distance from the lungs.
Fig. 144.—An air sac surrounded by blood capillaries.

the patient to get oxygen to the air sacs. How do the germs of pneumonia reach the lungs?

The linings of the air sacs are also injured by alcohol. This gets into the blood in the stomach and the intestine and comes out into the breath through the air sacs, as proved by the smell of the drinker's breath. The air sacs become inflamed, and, therefore, more liable to become diseased and injured for the work they have to do.

The use of cigarettes is so injurious that many States have laws against their sale. Their worst damage is to the lungs,

for much of the poison in cigarettes is inhaled and reaches the air sacs.

Summary.

The organs of respiration consist of the air passages and the lungs. Through the air passages the air enters the lungs, being warmed and freed from dust on the way. The lungs contain the air sacs, hollows at the ends of the fine air tubes. The air sacs have very thin walls and are surrounded by meshes of blood capillaries. It is here that the blood gives off the CO_2 and takes on the oxygen. The air in the lungs is renewed by the breathing movements of expiration and inspiration, due to the action of the diaphragm and the muscles that raise and lower the ribs. The air sacs may be injured by alcohol and tobacco, the use of which should be avoided. How to prevent disease germs from harming the respiratory organs is fully treated in the first part of this book.

Questions.

1. Where does the air enter the body? 2. Where does oxygen get into the blood and CO_2 leave it? 3. Name the air passages leading to the air sacs of the lungs. 4. Give reasons why we should breathe through the nose. 5. With a ruler held to your own face, indicate how the skull would have to be cut so that one might see the irregular bones of the nose shown in Fig. 134. 6. Where do adenoids sometimes develop? 7. If affected by adenoids why should we have these removed? 8. Why is cartilage tissue needed in the windpipe and air tubes? 9. How is voice produced? 10. How does the cavity of the mouth and throat help the voice? 11. Point out the cilia in Fig. 139. 12. From what part of A, Fig. 139, is the section B taken? 13. What is the function of the cilia? 14. How

is friction of the lungs against the wall of the chest prevented? 15. C, Fig. 139, is an enlarged portion of what part of A? 16. Similarly, explain the relation of D and A. Draw D, Fig. 139, placing the blood capillaries about it properly. (See Fig. 143.) 18. State two ways by which we breathe; explain fully. 19. Explain the meaning of Figs. 143 and 145. 20. How are the lungs often injured? 21. Name several diseases of the lungs and air passages and state in each case how the disease may be avoided.

CHAPTER XXX.

Ventilation.

Abundant reasons were given in the previous chapters why we need oxygen. Outside air consists of one part of oxygen to four parts of nitrogen, as explained in a preceding chapter. In more nearly exact figures outside air consists of 20.9 per cent

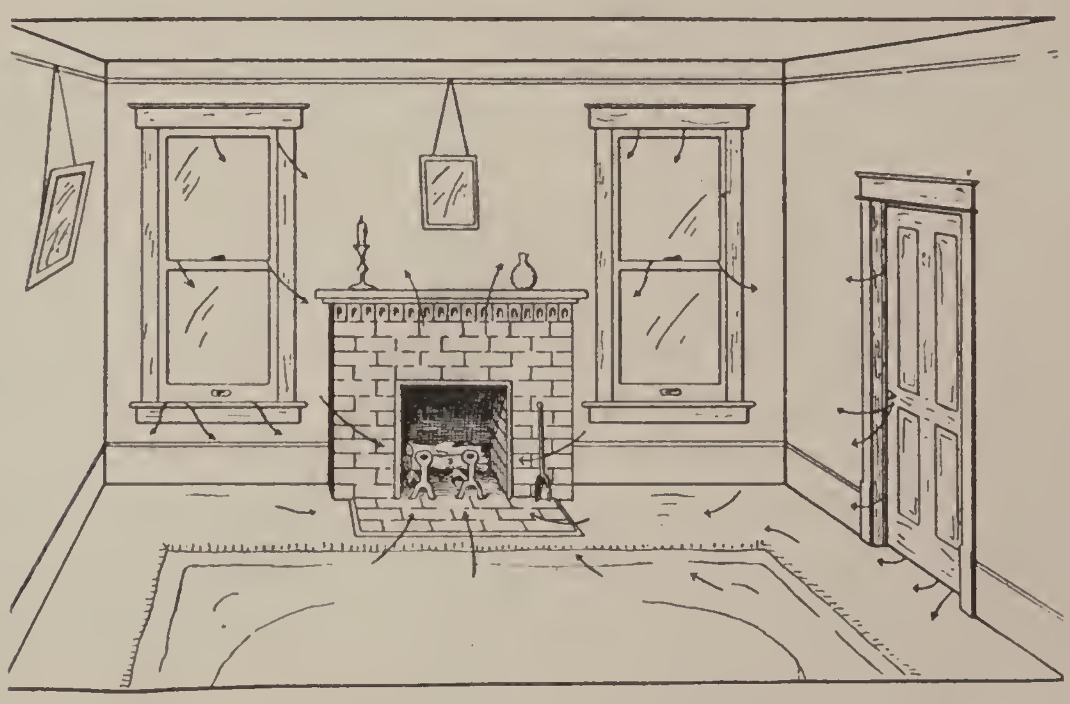


Fig. 146.—A fireplace is effective in ventilating a room. (Arrows indicate air currents.)

oxygen and 79.1 per cent nitrogen, with only a very slight trace of CO_2. But the air expired from our lungs has only 16.0 per cent of oxygen, 4.4 per cent of CO_2 and some water vapor; the nitrogen remains the same. There is given off of the lungs, in addition to these gases, organic matter, and it is

this that makes a room with foul air smell bad. The nose, therefore, is a good guide to detect bad air in rooms, provided one has first been in the open air; for after any one has been in foul air a while, he can no longer detect the bad odor with his nose. In that case, however, he can often tell that the air is bad from his sick and drowsy feeling and headache. Carbon dioxide and organic substances from the lungs and disease germs, therefore, poison the air where people breathe and cause sickness and, in extreme cases, death. The foul air about us should be removed constantly. In the open air the wind carries our foul breath away, but from the buildings we live and work in we must remove the foul air and bring in fresh air artificially. This process is called **ventilation.** In what sense is breathing a "ventilation of the lungs?" Just as we ventilate the lungs, so, if we build houses about us, we must ventilate these houses.

Every person needs 3,000 cubic feet of fresh air per hour. On a cold day this cannot be changed over five times in an hour. Every person should, therefore, be surrounded by 600 cubic feet of space in the room in which he stays. Figure out how far your school room falls short of this standard.

Principles of Ventilation.—To supply this fresh air, buildings like theaters, large churches, office buildings and some large schools have electric blow-fans that cause drafts of air, previously heated, to blow through the rooms and hallways. But we cannot here speak of this means of ventilation. Practically in our homes, and in most churches and schools, we must heat and ventilate without any special fans or air shafts. In short, ventilation depends upon the fact that heated air rises, because it expands, becomes lighter and is pushed up by cold air coming in from all sides, as can easily be seen from the following experiments:

Experiments.—(1) Take a common shoe box set it on end and cut two holes in it, as shown in Fig. 147. Place a lighted candle on the inside. After ventilation has begun, hold a smoldering match or a small rag at each hole and note the direction of the current as indicated by the smoke. (2) Now try the same experiment on the school room, if this is heated and the wind is not blowing too hard on the outside. Hold a burning match or a candle at the top of an open doorway or window and at the bottom and note the direction of the current in each case. (Fig. 148.)

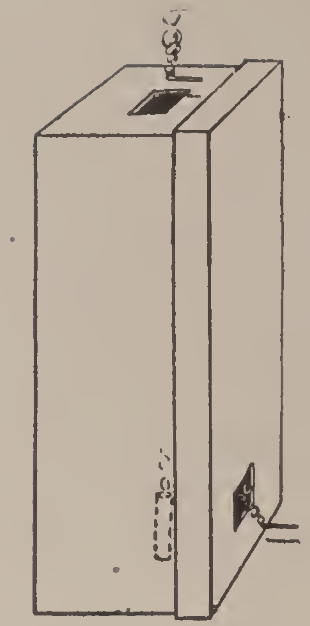


Fig. 147. — Experiment with shoe box and candle.

Study Fig. 146 and state the advantage of a fireplace from the standpoint of ventilation. How does the fresh air enter? Where does the foul air go out?

Fig. 148. — Experiment to show outgoing current of warm air and incoming current of cold air at a window.

Prevention of Draft.—From your observations on the experiments with the shoe box and the candle, how would you ventilate by means of windows only? You would lower the top sash and raise the bottom sash. If the stove stands in one end of the room, you should ventilate by the windows nearest the stove. Why?

But ventilating by this method is imperfect because the warm air passes out of the top of the window without doing the occupants of the room any good; and the cold air comes in at the bottom, causing a

draft. A better way is to leave the top sash in place, but raise the lower one and place a board in front of the open space, as shown in Fig. 149.

Ventilation of School Rooms.—All of these methods may do fairly well for homes during the day, for there are not many persons in a room at a time, and the doors are opened and closed frequently. But for the school room with thirty to sixty pupils breathing for some hours at a time, the methods given are absolutely inadequate. It is not too much to say that more children die from the indirect effects of foul air in the school room than from exposure on the way to and from school. There is absolutely no excuse except ignorance for building a school house that cannot be ventilated properly. The following points should be kept in mind:

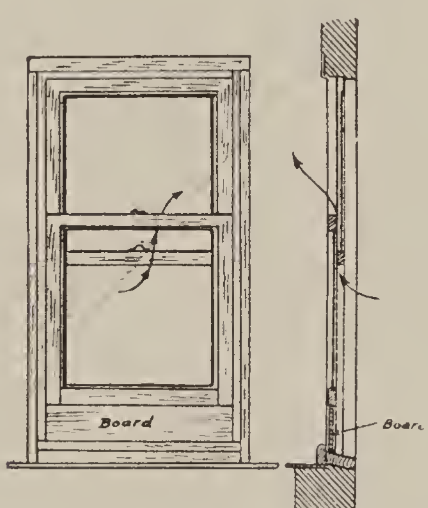


Fig. 149.—A simple means of ventilating in very cold weather.

1. Heated air rises. The arrows in Fig. 150 indicate the direction of the air currents. Describe the ventilation of this schoolroom in class with books open.

2. Fresh air should be furnished, but this should first be warmed. Where should the inlet therefore be? See Fig. 150. Note that warm fresh air circulates about the room.

3. This warm, fresh air should not be allowed to mix with the foul air of the room. The stove should, therefore be surrounded by an iron jacket reaching to the floor. (Fig. 150.)

4. There should be an outlet for the foul air. This is in connection with the chimney, which should have two compartments, as shown: one for the smoke, the other for the

foul air. The outlet should be near the floor, as shown (Fig. 150). Why? Draw a picture with an outlet at the top of the room and show by arrows how the air would pass out. A small fireplace instead of a mere opening is desirable. Other details can be gathered from the picture.*

Outdoor Sleeping.—Many people in Texas, as well as in

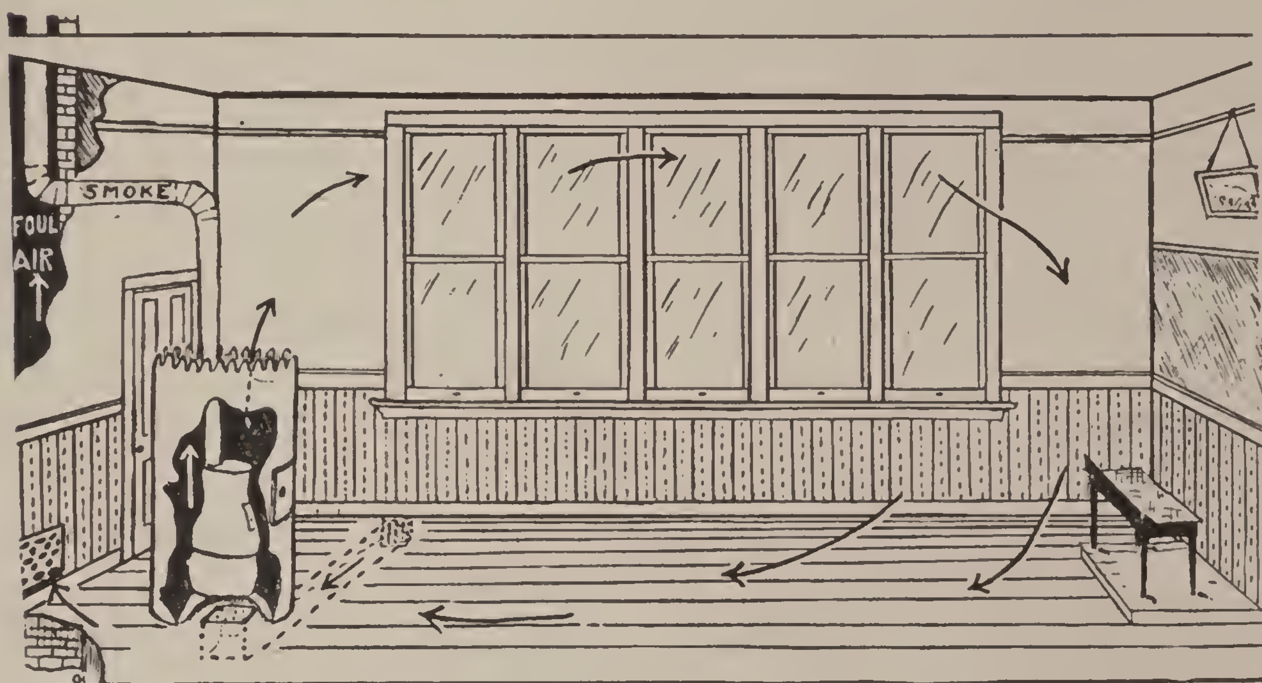


Fig. 150.—A schoolroom equipped with jacketed stove and ventilating flue. Arrows indicate direction of air currents. Fresh air comes through a grate in the floor, passes up between the hot stove and the jacket and supplies the room with warm, fresh air. The foul cool air passes through a grate in the wall behind the stove, into the foul-air vent of the chimney and thence to the outside.

all other parts of the civilized world, are sleeping out-of-doors. Indeed, patients suffering from such terrible diseases as tuberculosis and pneumonia are treated by the fresh air method. If oxygen is good for one who is sick it ought to be good

*Any school board in Texas desiring literature and expert advice on the subject of building school houses may obtain both free by addressing the State University or the State Superintendent of Public Instruction, Austin, Texas.

for one who is healthy. How much time do we spend sleeping each day? How many years in a lifetime of seventy is this? If all this time were spent in fresh air, you can readily see how much healthier we should be. Fig. 151 represents a sleeping porch constructed for outdoor sleeping. If one cannot have this, it is important that one sleep with windows open, of course keeping well covered and avoiding direct drafts.

Fig. 151.—A sleeping porch Suitable for Texas.

Summary.

The rooms we live in should be well ventilated to keep the air relatively pure. This is almost as important as breathing itself. Where many persons stay in a room for a long time, as pupils in a school room, there should be means of ventilating the room without cold drafts. This is best accomplished by means of a ventilating chimney and a jacketed stove so arranged as to furnish warm fresh air and remove cold foul air continuously.

Questions.

1. Why is oxygen needed by the body? 2. How does expired air differ from inspired air? 3. What are the harmful substances given off by the breath? 4. Define ventilation. 5. How can you tell if your school room is poorly ventilated? 6. Explain Figs. 147 and 148. 7. Mention some rules for ventilating an ordinary room. 8. Fully explain the circulation of air in Fig. 150. 9. Where does the fresh air come in? 10. Where does the foul air pass out? 11. How is the foul air of the room kept from mixing with the fresh air coming in under the stove? 12. What are the special advantages of sleeping out-of-doors?

CHAPTER XXXI.

The Circulation of the Blood.

In the preceding chapters much was said about the blood and the lymph and their functions. At this stage of your study, it is perfectly plain to you that the main function of the blood is to **carry** the useful materials of food and oxygen to the cells of the body and to take away the harmful waste substances. Fig. 152 represents the relation of a body cell to the blood and to the lymph. The bood flows in a system of closed tubes. It is the thinnest and smallest of these, the capillaries, that carry the blood close enough to the cells of the body so that the food and waste substanecs may be exchanged between the blood and the cell. The lymph surrounding cells and capillaries forms the medium through which the food and waste materials pass to and from the cells. Capillaries also come close to the cells of the glands (Fig. 117), the villi (Fig. 122), and the air sacs of the lungs (Fig. 144), as has been shown. In short, the capillaries of the blood come close to each and every living and working cell of the body.

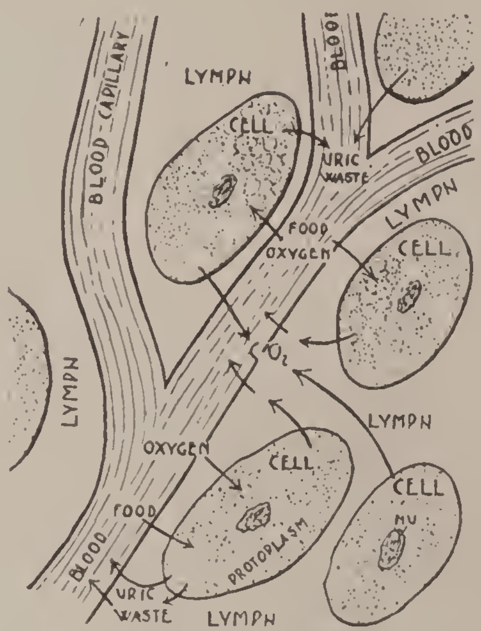


Fig. 152.—Blood capillaries come close to all of the cells of the body.

The Blood as a Carrier.—To take on a load of food or oxygen the blood must go to the proper organ to get it, just as your grocer must go to the freight depot to get the groceries before he can supply you with them. To the supplying organs the blood is pumped by the heart: first to the lungs, where it receives its load of oxygen. Here the arteries break up into capillaries which surround the air sacs. Through the thin capillary wall and the thin walls of the air sacs the blood takes on oxygen and gives off carbon dioxide. The oxygenated blood then goes back to the heart to be pumped out again to all parts of the body. Similarly, the blood passes through the stomach and the small intestine and takes on food, which is carried to the heart to be pumped out to all of the cells.

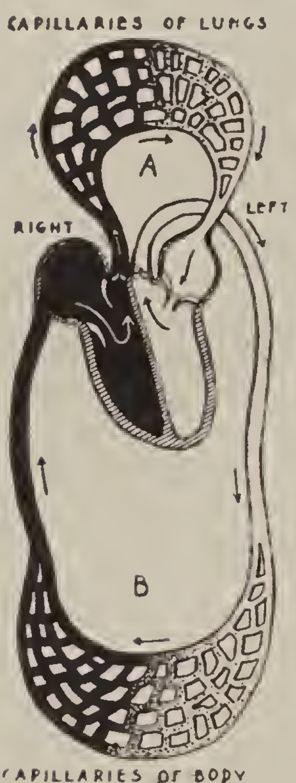


Fig. 153.—The lesser circulation (through the lungs) and the greater circulation (through the body).

The Lesser and the Greater Circulation.—It is to be noted that a special trip is made to the lungs; the blood goes to these organs and then straight back to the heart. This is the lesser circulation (Fig. 153). When the blood starts out again from the heart it goes to all parts of the body, passes through the capillaries among the cells and returns again to the heart. This is the greater circulation. (Fig. 153.)

In short, the heart pumps blood into arteries, these break up into capillaries in the lungs and other parts of the body, and the capillaries combine to form veins, which return the blood to the heart. It is easy to see how the blood is forced out by the pumping action of the heart, but it is not so easy

to see how the blood is forced back to the heart. In this chapter we shall study more about the circulation of the blood.

Observation on the Circulation of the Blood.—If you hold your hand up to a bright light you see the red color plainly through the skin. But you cannot see the blood flow. If you chop a chicken's head off, the blood will run out and the blood will "flow;" but this is not circulation. Very favorable subjects for studying the circulation are the thin web of a frog's foot, and the thin membrane at the sides of a tadpole's tail. To see this requires a compound microscope. But the sight is so beautiful that it is well worth while going to some trouble to have a high school teacher or a local physician bring his microscope and show you the sight. Tadpoles can be found in permanent pools of water at almost any season in Texas. Secure one and put it in place, as in Fig. 154. The tadpole is lightly covered with cotton (C) kept wet with water. The piece of tin is bent at right angles and has a hole (H) through which the tail of the tadpole protrudes. This hole should not be so large as to allow the animal to slip through. The tail is laid over the slit (S) in the shingle so as to let the light through in viewing a thin part of the tail, as at point X, with a microscope. Here the circulation of the blood can be well seen. A thread may be strung over the tail to keep it from flipping up during observation. If you are fortunate enough to see this, note that the blood flows through the capillaries in a steady stream and not in jerks.

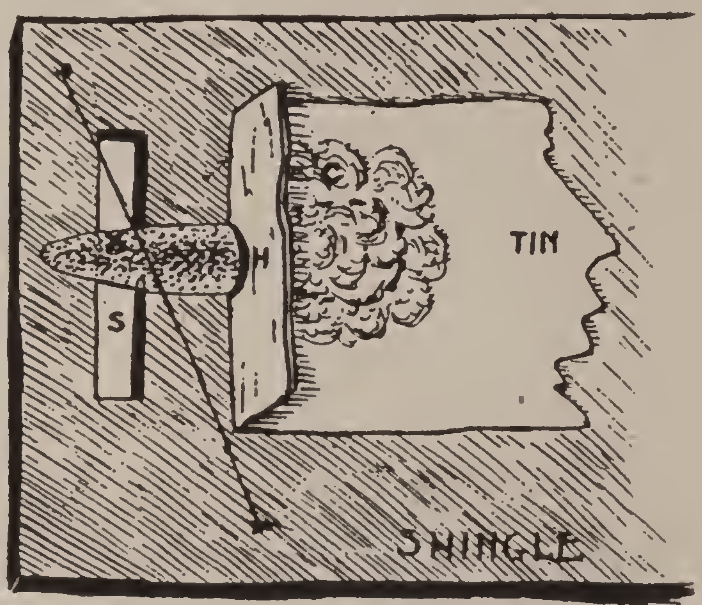


Fig. 154.—Showing manner of mounting a tadpole to observe the circulation of blood in arteries, veins and capillaries. (See text.)

How the Blood Circulates.—The word circulate means to

travel in a circle. When we say the blood circulates we imply that it continues to return to its starting point. We noted above that this is the case. The blood is forced on its journey by the **heart.** From the heart the blood travels in **arteries.** These arteries divide into smaller and smaller branches until the finest hair-like arteries become **capillaries.** (Fig. 155.) The capillaries combine to form **veins,** which continue to unite as they proceed to the heart. The blood passes through two sets of capillaries on one complete round through the body: through the capillaries of the lungs, and through the capilaries in different parts of the body, but each time returning to the heart to be pumped out again, as shown in Fig. 153. In what sense are there two circulations? In what sense is there really but one complete circulation?

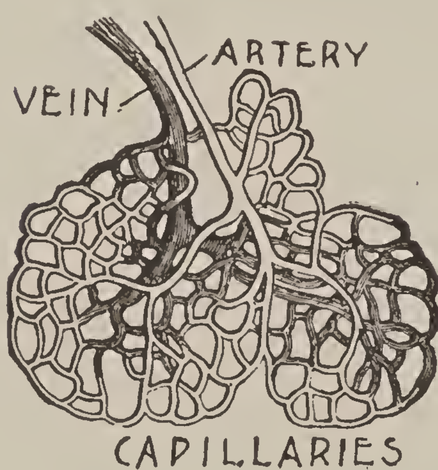
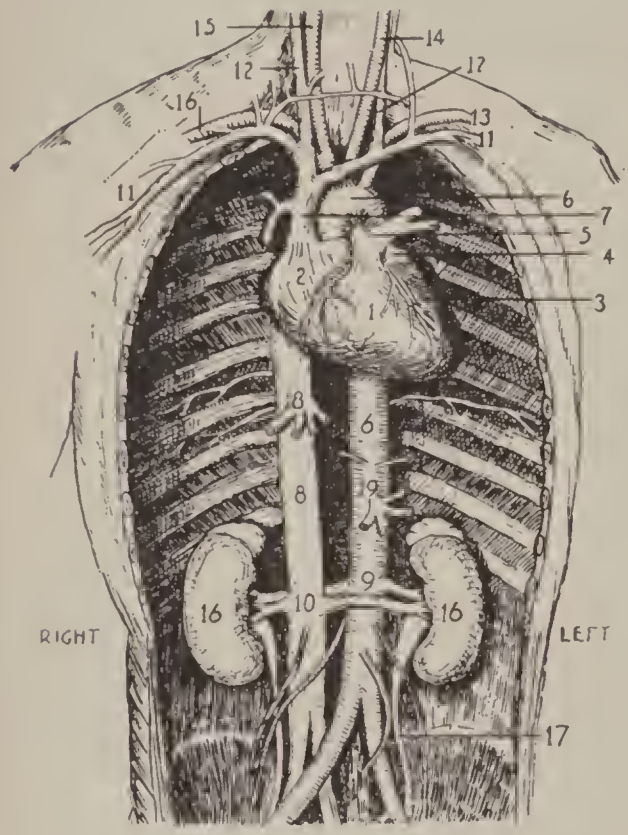


Fig. 155.—A net work of blood capillaries connecting an artery with a vein.

The Heart.—The heart has a single duty to perform: to pump blood. It is, therefore, composed largely of muscle and connective tissue. It is located in the thorax, between the lungs, just a little to the left of the middle line, with the point directed to the left. (Fig. 80a and Fig. 156.) We can "feel" the beat of the heart between the fifth and sixth ribs. As this organ is in motion a large part of the time we would expect it to be protected against friction? How are the lungs protected against friction? The stomach and the intestine? Name the coverings of the lungs and of the abdominal organs. The heart is likewise covered by a two-layered bag, the **pericardium,** with a lubricating liquid between the layers.

The heart is divided into two halves by a solid partition wall. No blood can pass from one side of the heart to the other except by going around through the capillaries. What capillaries must the blood pass through to go from the right



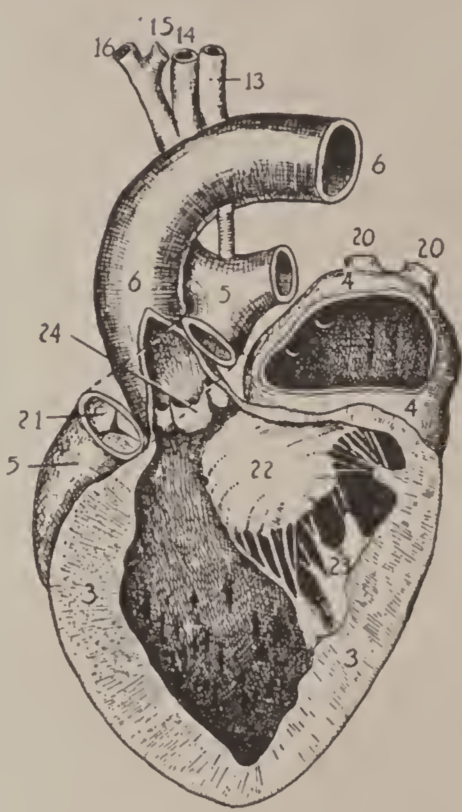


Fig. 156.—A view of the principal arteries and veins. 1, right ventricle; 2, right auricle; 3, part of left ventricle; 4, corner of left auricle; 5, pulmonary artery (to lungs); 6, aorta; 7, vena cava descending; 8, vena cava ascending; 9, renal artery (to kidney); 10, renal vein (from kidney); 11, right and left subclavian veins; 13 and 16, left and right arteries; 12, jugular veins; 14 and 15, left and right carotid arteries; 18, veins from abdominal organs; 19, arteries to abdominal organs.

Fig. 157.—Left side heart, with left ventricle (3) and auricle (4) cut open. 20, two of the four pulmonary veins, from lungs; 21, valves of pulmonary artery (5), almost closed; 24, similar valves of the aorta (6), with part of the aorta cut away; 22, valve between auricle and ventricle; 23, cords and muscles holding the valves.

to the left side? (Fig. 153.) Each half of the heart consists of a thin-walled chamber called the **auricle,** to receive the blood, and a thick-walled chamber called the **ventricle, to** pump the blood out into the arteries. How many chambers has

the heart? Name them. Two large veins bring the blood back to the heart from all parts of the body: the **descending vena cava,** from the upper part of the body (7 Fig. 156), and the **ascending vena cava,** from the lower part (8). One **pulmonary artery** (5) leaves the right ventricle for the lungs, and **four pulmonary** veins (20) carry the blood back to the left auricle. One large artery, the **aorta** (6), takes the blood out of the left ventricle to all parts of the body. How many

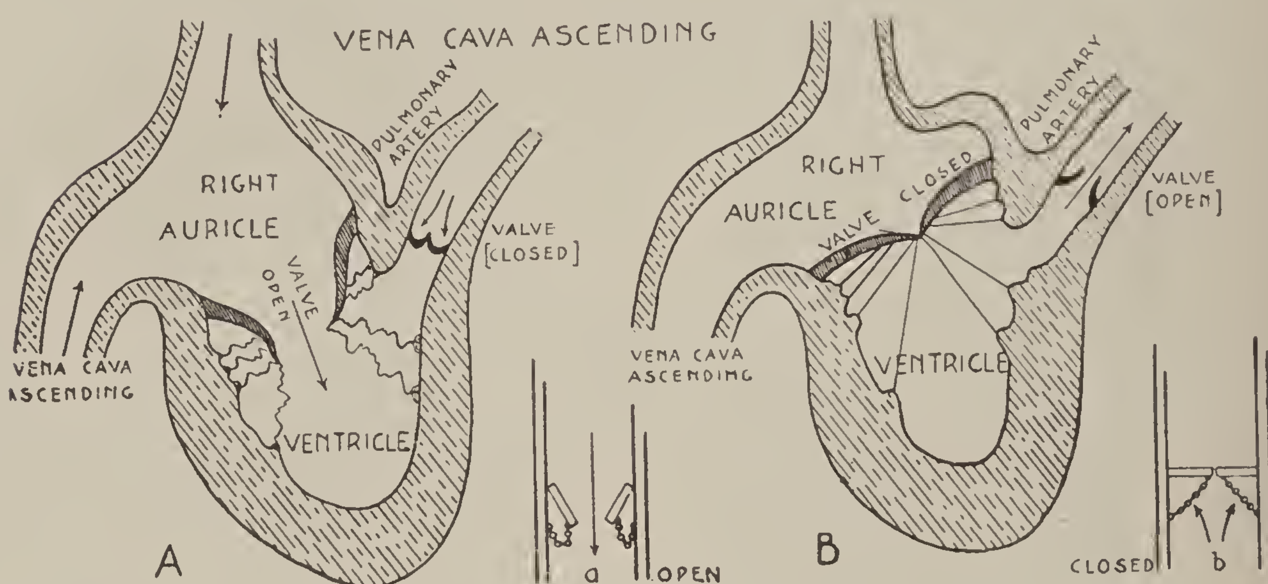


Fig. 158.—Diagrams of heart, showing action of valves: A, at expansion of heart; B, at beginning of contraction. Diagrams a and b illustrate action of valves between auricle and ventricle.

veins come into the heart? How many arteries leave the heart?

The Action of the Heart.—After the blood has come into both of the auricles, these contract and push the blood into the ventricles. Then the ventricles contract, pushing the blood into the arteries. The contraction of the ventricles constitutes the "heart beat." Since the arteries are already full, pumping more blood into them makes them expand; this expansion

is called the **pulse.** Since this happens at every heart beat, you can count the heart beat by feeling the pulse. That the blood does not go back into the auricle during the contraction of the ventricles is due to the presence of flaps of connective tissue, so placed and held by cords (Fig. 158 A) that the blood catches under the flaps and closes them after the manner of Fig. 158 B. This is illustrated further by diagrams a and b of the same

FIG. 159.

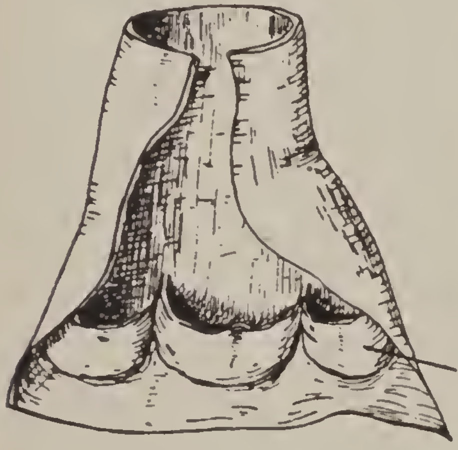


FIG. 160.

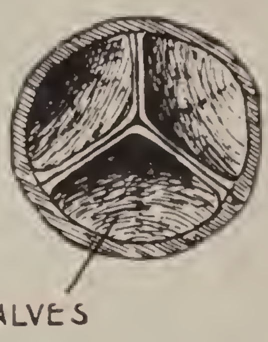


FIG. 161.

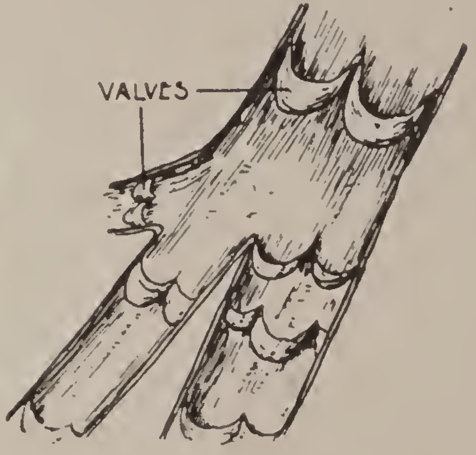


Fig. 159.—Valves in aorta. (Compare with Fig. 157.)
Fig. 160.—Valves shown in Fig. 159, closed, as seen from within the aorta.
Fig. 161.—A vein with several branches laid open, showing valves.

figure. So, too, when the ventricles expand and rest between beats, the blood, under pressure in the arteries, tends to gush into the ventricles. It is prevented from returning, however, by pockets fastened to the walls of the arteries shown at 24 in Fig. 157, and again, more enlarged, in Figs. 159 and 160. Such flaps or pockets that make the blood go in one direction are called **valves.** Point out the valves of the heart in the illustrations, and explain how each acts. How many sets are there?

Observation Work.—1. Find the pulse on your wrist and count the number of heart beats per minute. (2) Listen to the heart beat of

some person by pressing your ear against the chest or back on the level of the heart. You will hear two sounds at each beat. These are partially due to the closing of the valves, the "slamming of the doors." Which valves close to make the first sound? (Remember that the right and left ventricles contract and expand together.)

(3) Study Figs. 162 and 156 and trace the blood in a circuit through the body. Trace it from the head back to the head; from the lungs back to the lungs; from the liver back to the liver.

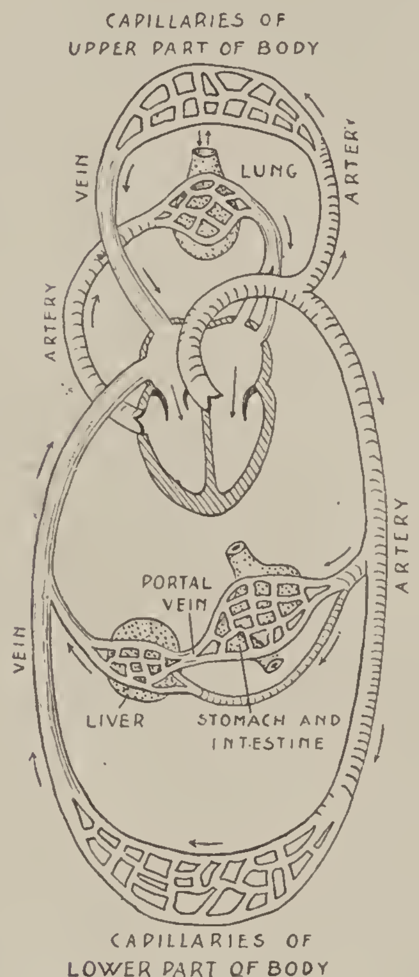


Fig. 162.—Diagram of the circulation of the blood (compare with Fig. 153).

There is one vein that deserves special mention. It is the **portal vein.** (Fig. 123.) It begins in capillaries in the stomach and intestine and ends in capillaries of the liver. It is the only blood vessel in the body beginning and ending in capillaries. Where do all other veins begin and where end? Arteries? What substances pass through the portal vein?

Arteries and veins differ, as has been seen, in the direction of their flow. Which flows away from the heart? They differ also in the thickness of their walls. (Fig. 163.) The veins have less elastic connective tissue and muscle than the arteries. The veins, furthermore, have valves throughout their course, as shown in Fig. 161. Where are the only valves in the arteries? (Fig. 157.)

In the arteries the blood is under pressure. When an artery is cut, therefore, the wound stands open, blood spurts

out and a person is in great danger of bleeding to death. The arteries are placed deeper under the skin and muscles than the veins. When an artery is cut, to stop the bleeding, pressure should be applied between the cut and the heart, as has been described in Chapter XLV.

How the Blood Gets Back to the Heart.—Contraction of the heart and elasticity of the arteries send the blood coursing toward the capillaries, where the blood does the main work. Now let us see how the blood is forced back to the heart. The pressure from the arteries pushes the blood through the capillaries into the veins. But this is not sufficient to carry the blood very far on its way to the heart, especially from the feet, for example. The blood is helped along in two ways: It is partly sucked and partly squeezed on its way. At every inspiration, the chest is expanded, which causes the blood to be drawn toward the chest. The veins are squeezed every time a muscle contracts and becomes hard and firm. Now the blood tends to flow backwards from the heart as well as forwards toward the heart, and is prevented from flowing backwards by the valves in the veins as illustrated by the accompanying diagrams (Figs. 164 and 165).

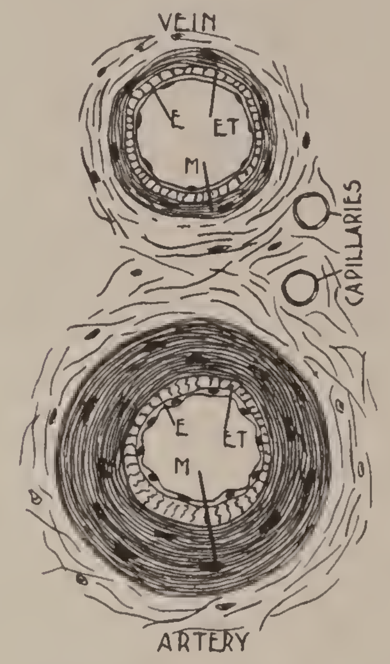


Fig. 163.—Cross section of artery, vein and two capillaries. E, epithelial lining (the only tissue in the capillaries); ET, elastic tissue; M, muscle tissue.

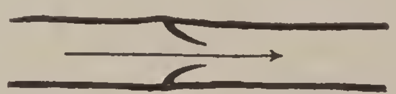


Fig. 164.—Valves in vein, open.

Fig. 165.—Valves in vein, closed.

Observation Work.—You can easily locate the valves in a vein on the back of your hand or on your wrist. Hold your hand down and press the muscles of your forearm on the edge of the desk. This will make the veins of the back of your hand stand out. Now, with the blunt end of your pencil, press along a vein toward the fingers (away from the heart) and note that the vein does not fill from the end toward the heart.

You yourself can now tell why deep breathing is beneficial to the organs of circulation. State also how exercise helps the flow of blood through the muscles, and why the muscles used a great deal are darker* than others. For the same reason rubbing a part of the body helps to increase the circulation.

Summary.

The blood circulates in a system of closed tubes: the heart, to pump the blood; the arteries to carry the blood to the capillaries; these to connect the arteries with the veins; and the veins to carry the blood back to the heart. The capillaries are short and thin-walled; it is in the capillaries, therefore, that the blood exchanges food for waste substances with the cells. The blood is partly forced back to the heart by the pressure of the muscles against them, and by the action of the valves that prevent the blood from flowing backwards. Exercise, therefore, helps the flow of the blood. Exercise also helps the blood to return to the heart in that it requires deep breathing, for the breathing movements suck the blood toward the chest, and therefore toward the heart.

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*Compare, for example, the breast and the leg muscles of a chicken.

Questions.

1. What is the chief function of the blood? 2. In what blood vessels does the blood take on and give off its loads? 3. What does the blood take on (a) in the lungs? (b) in the stomach? (c) in the intestine? (d) from the various cells of the body? 4. What does the blood give off at those cells? 5. What does it give off in the lungs? 6. What is meant by the lesser circulation? 7. Name as many differences as you can between arteries and veins. 8. Of what tissue is the heart chiefly composed? 9. When does the heart "rest?" 10. What is meant by pulse? 11. From Fig. 158 describe the action of the heart in pumping blood. 12. What is the use of the valves between the auricles and the ventricles? 13. What is the use of those at the openings of the arteries? 14. How many times does your heart beat each minute? 15. Where is the portal vein and what does it carry? 16. Tell how the blood gets back to the heart. 17. How does exercise help the circulation? 18. How does deep breathing help the blood flow? 19. Trace the blood from the right auricle to the left ventricle. 20. Trace it around to other parts of the body as the teacher may direct.

CHAPTER XXXII.

The Blood and the Lymph.

What the Blood Is.—We have seen that the blood is the carrying agent of the body, carrying food and oxygen to the cells and waste matter away. Most of these substances are carried simply in solution, for blood is largely water containing dissolved substances.

Review Work.—Make a list of all the substances you would expect to find dissolved in the blood, studying in this connection pages 179 to 183, and Figs. 125 and 128.

Blood contains certain cells called **corpuscles**: red and white. They are extremely small, one small drop the size of a pin head containing several million red ones and thousands of white ones. The red corpuscles are of the shape shown in Fig. 166. B, C, and D of this figure show red corpuscles, highly magnified, in flat view, end view and oblique view. Describe the shape from these drawings. White corpuscles are shown at F and G. The blood is easily studied with a large microscope and should be seen if possible. The subject will certainly be a revelation to you, for who would think, after looking at a

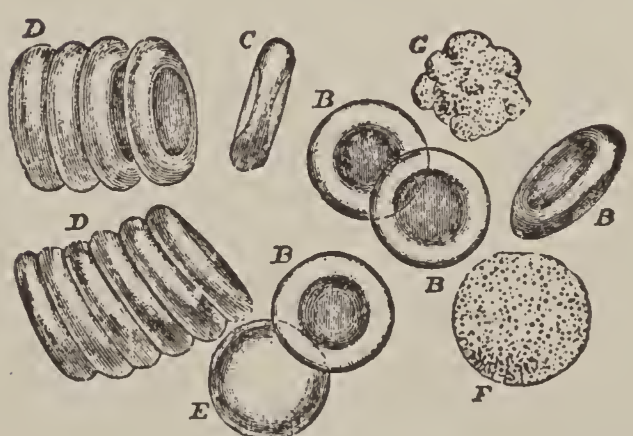

Fig. 166.—Blood corpuscles, highly magnified. B, C, D, red, and F, G, white blood corpuscles.

drop of blood with the naked eye, that it is made up of so many and so wonderful things?

The red corpuscles are just of the right size to pass through the capillaries single file, as can plainly be seen in the tadpole's tail (page 207). Now, when you are told that it is the duty of these little cells to carry oxygen from the air sacs of the lungs you will readily see why they must pass single file. At a circus the crowd passes in single file by the ticket window to get the tickets, and in the same way deposits the tickets at the entrance. Copy Figs. 143 and 145 and add to your drawing red corpuscles in the capillaries.

Just how the corpuscles carry oxygen is not easy to understand. Oxygen in the air is a gas, and in that condition a little oxygen takes up a great deal of room. The oxygen "makes itself small" by uniting with a substance called **hemaglobin**, which is found in the red blood corpuscles. When there is much oxygen present, as in the air sacs of the lungs (Fig. 143), the hemaglobin causes the oxygen to unite with it, and in this condition the oxygen takes up almost no room. But the oxygen will easly let go of the hemaglobin when the blood reaches a place where oxygen is scarce, as out among the working cells of the body. (Fig. 145.)

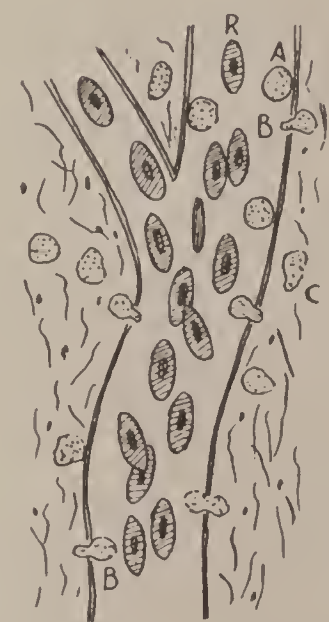

Fig. 167.—Blood vessel of frog, showing how white blood corpuscles pass out of the blood vessel. A, corpuscle within the vessel; B, partly and C, entirely outside the vessel. R, red corpuscle.

The white corpuscles differ from the red ones in that they can change their shape, and also in that they have quite a different work to do. They are the "soldiers" and "scavengers" of the body. What is a soldier's duty? A scavenger's?

The white corpsulces fight for us, swallowing and digesting the disease germs in the body. (Fig. 15.) They likewise take up fragments of worn-out protoplasm lying among the cells. If you stick a splinter in your finger, the white corpuscles travel to the spot and try to surround the splinter and get rid of it by "festering" it out of the body. For these corpuscles can get out of the capillaries by squeezing through them between the cells just as you would squeeze a large-sized rubber ball through a small crack in the fence. (Fig. 167.)

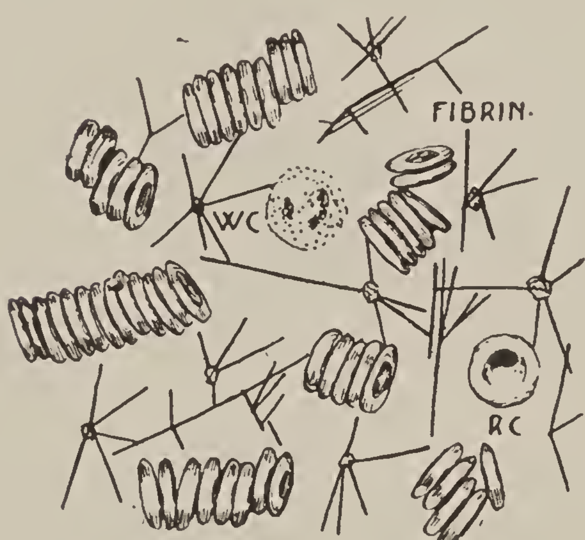

Fig. 168.—A bit of blood clotted, showing fibrin strands; RC, red, and WC, white blood corpuscles.

Where the Corpuscles Are Produced.—Both kinds of corpuscles are continually being worn out and new ones produced. The red ones are made by certain cells in the red marrow of flat bones and in the spleen; white ones by certain cells in the spleen and lymph glands. What happens to the body if we have too few white blood corpuscles? What do the cells lack if the blood has too few red ones? If the red ones are scarce in the blood of a person he is said to suffer with **anemia.** In malarial fever the germs destroy the red corpuscles; hookworms use up a great deal of a person's blood. A patient suffering with either disease is anemic and shows it by a pale or sallow complexion. It is, therefore, important that we should do everything to help the body produce many corpuscles. Plenty of fresh air, good food, sleep and exercise are conducive to the production of blood corpuscles.

Clotting of Blood.—How does the blood act when it runs out

of a cut or other wound? It clots, you say. This is due to the strands of **fibrin** (Fig. 168), a kind of proteid, separating out or coagulating, just as the white of an egg, another kind of proteid, coagulates on heating. There is a proteid in the blood that coagulates and changes to fibrin merely on exposure.

Observation Work.—Leave a bottle at the butcher's, with the request that he have it filled with ox blood. When you call for the bottle and take it to school, a dark red clot will have formed. (Fig. 169.) What does this clot consist of? (Compare Fig. 166 with Fig. 168.) The straw-colored liquid on top is **serum**; this contains water, foodstuffs and wastes in solution. It also contains antitoxins when these are present in the blood. (Fig. 128.)

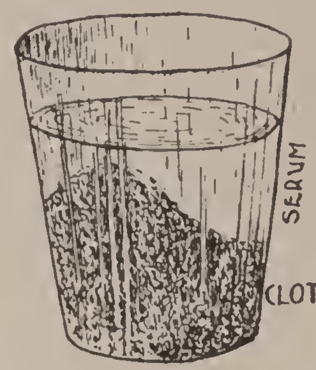

Fig. 169.—A tumble of clotted blood.

The Lymph.—There is another fluid in the body very much like the blood, namely, the lymph. Read again pages 179 and 180 and describe where the lymph is found. Lymph differs from blood in that it lacks red corpuscles and clots more slowly. Perhaps you remember when last you had a blister from a burn. The blister was filled with thin lymph. The fluids in the pericardium, between the pleurae and around the abdominal organs are kinds of lymph.

After studying Fig. 152 you must come to the conclusion that the function of the lymph is to fill the spaces among the cells of the body and to form the means of communication between the cells and capillaries. Which substances are given to and which taken from the cells in Fig. 152? A little thought will also tell you where all of the lymph probably comes from: it oozes out of the blood capillaries, and is, we might say, the liquid part of the blood. The cells also add waste substances to the lymph. The lymph helps the blood to carry off these wastes.

Lymphatics.—Now the lymph must be constantly renewed and therefore constantly drawn off. It does not pass back into the blood through the capillaries, but has vessels of its own, the lymph capillaries and lymph veins, that carry the lymph away. The lymph capillaries run out from the lymph spaces (Fig. 170) and then unite into veins just as the blood vessels do. The lymph veins all finally unite into two large lymphatic ducts, the larger of which is on the left side, and is called the **thoracic duct.** Fig. 171 tells where the two ducts are located. Note that they empty into large veins above the heart, where the lymph again mixes with the blood. Lymph, therefore, comes mainly from the blood and runs back into the blood.

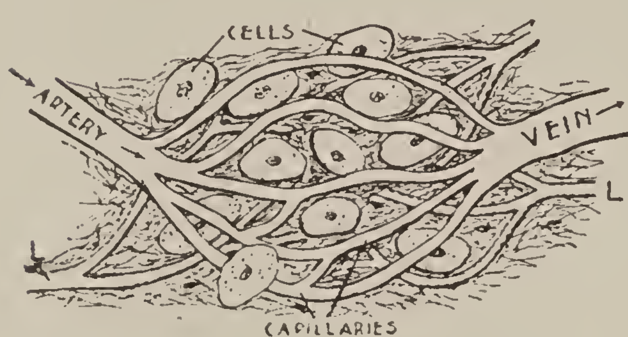

Fig. 170.—Lymphatic capillaries (L) beginning in the lymph spaces among cells of the body.

There is another special starting point for the lymph . Review what was said about the lacteals and tell where they are and what these lymph vessels carry into the blood. The lacteals unite and empty into the thoracic duct. (Fig. 123.)

Lymph Nodes.—On their way the lymph veins pass through knots of tissue special organs called **lymph glands,** or **lymph nodes.** Here certain changes occur in the lymph; disease germs are stopped here and kept from going into the blood. The lymph nodes also produce corpuscles, as mentioned above. The spleen is a large lymph node. Fig. 171 shows the location of some of the lymph nodes of the body. Fig. 172 represents a single one cut open. Note that the lymph vessels have cross lines on them. These show the location of valves, the use of which is exactly that of the valves in the veins. The sucking

action of breathing and the contraction of the muscles force the lymph along exactly as the blood is forced along in the veins.

Observation Work.—Have one pupil stand absolutely still until he gets tired and at the same time have another pupil walk slowly about. Why is it harder to stand perfectly still than to walk?

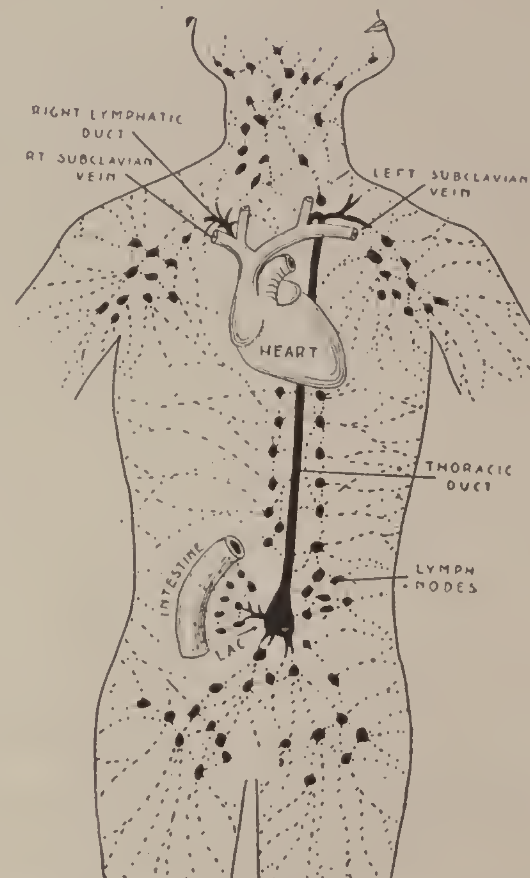

Fig. 171.—The lymphatic system. LAC, lacteals.

Hygiene of Circulation

Exercise.—We have noticed that the contraction of the muscles helps the circulation in that it increases the flow of the blood in the veins and of lymph in the lymphatic vessels. Exercise further helps the circulation by increasing the number and depth of the breaths. But it also helps in exercising the heart.

Experiment to show the effect of exercise on the heart. Count the pulse after fifteen minutes of rest. Stand up one minute and make a count; walk a minute and count again; run or hop a minute and make another count. Why does exercise make the heart beat faster? Review pages 181 and 185 before trying to answer this fully.

We must exercise the heart, otherwise it will give out in cases of emergency, such as sickness or having to run to catch a train. So we should exercise every day sufficiently to make the heart beat strongly for a while. But we must guard against too severe exercise, such as boys and girls in the grammar grades are likely to engage in. At this age the heart grows

very fast. Foot racing, bicycle riding, football and even tennis may easily be overdone. Grammar school boys should not attempt to run more than a fifty-yard dash or a one-fourth mile relay race.

Alcohol.—Alcohol makes the heart beat faster and so interferes with nature's way of regulating the beat, and thus overworks the heart. It makes the blood vessels of the skin enlarge and so forces more blood into the skin, which thus becomes red. Since there is more blood in the skin the body cools off faster and is therefore not warmed but cooled by alcohol. In cold weather what kind of food should be taken in place of alcohol? No one who uses alcohol could ever reach the North or the South Pole. It is said that alcohol taken in small quantities makes a person "fat." But this fat is unhealthy, and if the fat is deposited about the heart, it becomes dangerous. Many deaths occur from diseases, notably pneumonia, because the heart fails to do its duty. You have heard it said of a sick person, "Tomorrow will come a turning point in the disease," or "If he lives until tomorrow, he will get well." How necessary it sometimes is to have a heart that will hold out just one day longer! We cannot afford to do anything that will injure this wonderful organ, the heart.

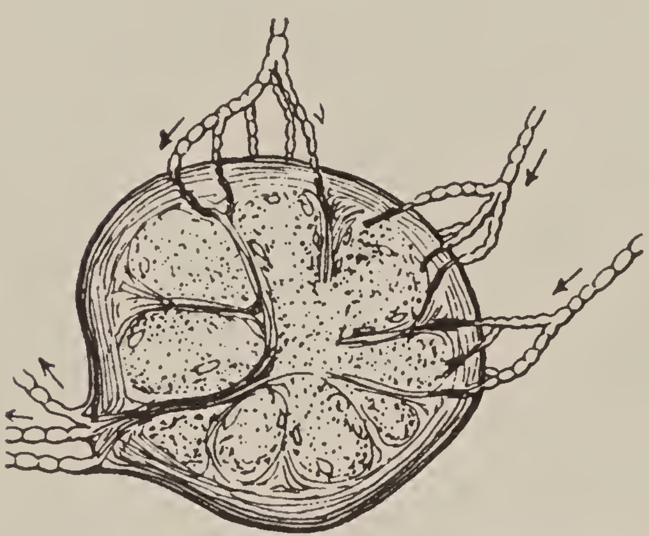

Fig. 172.—A lymph node, with lymph vessels.

Tobacco.—Doctors speak of an "alcohol heart" and a "tobacco heart:" an unsteady, palpitating, fluttering, unreliable heart. Tobacco is particularly harmful to the young boy of

grammar or high school age. At that time the heart grows rapidly, and any interference is sure to lead to permanent injury. If a boy thinks he must smoke, he should wait until he is at least twenty-one.

Summary.

The blood contains red corpuscles and white ones. The red corpuscles have to do with respiration, for they carry oxygen from the lungs to the cells of the body. The white corpuscles have to do with fighting of disease germs in the body. The number of both kinds of corpuscles is increased by correct habits of living. The blood also contains a proteid that forms fibers of fibrin, which makes blood clot. The lymph surrounds the cells of the body. It is moved along and collected in lymph vessels that empty into the blood vessels above the heart. Exercise is necessary to strengthen the heart and to improve the circulation generally by contraction of the muscles and by deep breathing. Alcohol and tobacco affect the heart and arteries, often injuring them permanently.

Questions.

1. What have the red corpuscles to do with respiration? 2. What is the work of the white corpuscles? 3. In what organ of the body is each kind of corpuscle made? 4. What is anemia? 5. How do hookworm or malaria cause anemia? 6. What is the value of clotting of blood? 7. What is serum? 8. What parts of the blood does the clot (Fig. 169) contain? 9. Where is lymph found in the body? 10. Describe a lymph vessel. 11. Is it more like a vein or an artery? Why? 12. What does the thoracic duct carry? 13. Where does it empty? 14. What are the lymph nodes? 15. How does exercise help the flow of lymph? 16. How does exercise help the heart? 17. Why is it dangerous for young boys to exercise too violently?

CHAPTER XXXIII.

Excretion.

The Meaning of Excretion.—We have thus far considered a number of activities of living cells, for example, the taking of food, assimilation, growth, respiration. You should be able to tell in your own words what each of these means. Digestion, absorption, assimilation, growth are all building-up processes which end in the making of protoplasm by the cells of the body. Then oxygen comes to the cell and burns up the protoplasm and the foods, and thus tears down or breaks up the protoplasm. Oxidation is a tearing-down process, but it is necessary in order that energy for warmth and motion may be produced. But not only is energy produced but waste substances result from oxidation. The production of **waste substances** is called **excretion.** Every cell excretes waste substances (Fig. 152), and the blood carries them to the proper organs which remove them. The organs that remove waste substances from the blood are called excretory organs.

The Waste Material of the Cell.—We have already studied one set of excretory organs,* the lungs, which remove carbon dioxide from the body. Respiration thus includes two phases: the taking in of oxygen and the removing of carbon diox-

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*We shall not include here the **large intestine** that removes undigested foods, worn-out digestive juices and bacteria from the alimentary canal. It is, of course, of extreme importance to health that decaying remnants of the food should be removed daily from the body.

ide. (Fig. 129.) The lungs are, therefore, in a sense, organs of excretion that remove most of the used-up carbon from the body.

Another important waste substance is that containing nitrogen, and is called uric waste. This is removed by the kidneys and by the sweat glands of the skin.

Thus it is seen that there are two main kinds of waste substances: **carbon dioxide**, containing most of the carbon removed from the blood by the lungs, and **uric waste**, containing all of the nitrogen and removed from the blood by the kidneys and skin.

The liver is sometimes included as an excretory organ; but this is only partly correct. It does not remove waste substances but changes them to a form more easily removed by the kidneys and skin.

The Kidneys.—The location and shape of the two kidneys can be seen in Fig. 80a; also at 16, in Fig. 156. Fig. 173 represents one kidney, opened, showing the internal structure. As the uric waste is carried to the kidney by the blood there are, as we would expect, a large artery (renal artery) leading to the organ, and a large vein (renal vein) carrying the blood away. (9 and 10, Fig. 156.) Which of these, artery or vein, has the smaller amount of impurities in it? So you see that arteries do not always carry "purer" blood than the corresponding vein. Give another example of this occurrence.

The kidney is made up of a very large number of fine tubes or tubules that begin near the outer surface as little pockets of epithelial tissue. The pockets are indicated by dots (C, Fig. 173), and the tubules by lines (PY). These tubules pass toward the hollow of the kidney at H. Four tubules, enlarged, are shown at T in the same figure, two near the top and two near the middle of the section represented. From Fig. 174 the course of

the capillaries of the blood can be seen. A bunch of capillaries (Cap. 1) enters the pocket at the head of the tubule, and more capillaries surround the tubule itself (Cap 2). The cells that take water and waste substances out of the blood are the cells shown at X, Y and Z. The kidney is in a sense a

FIG. 173. FIG. 175. FIG. 174.

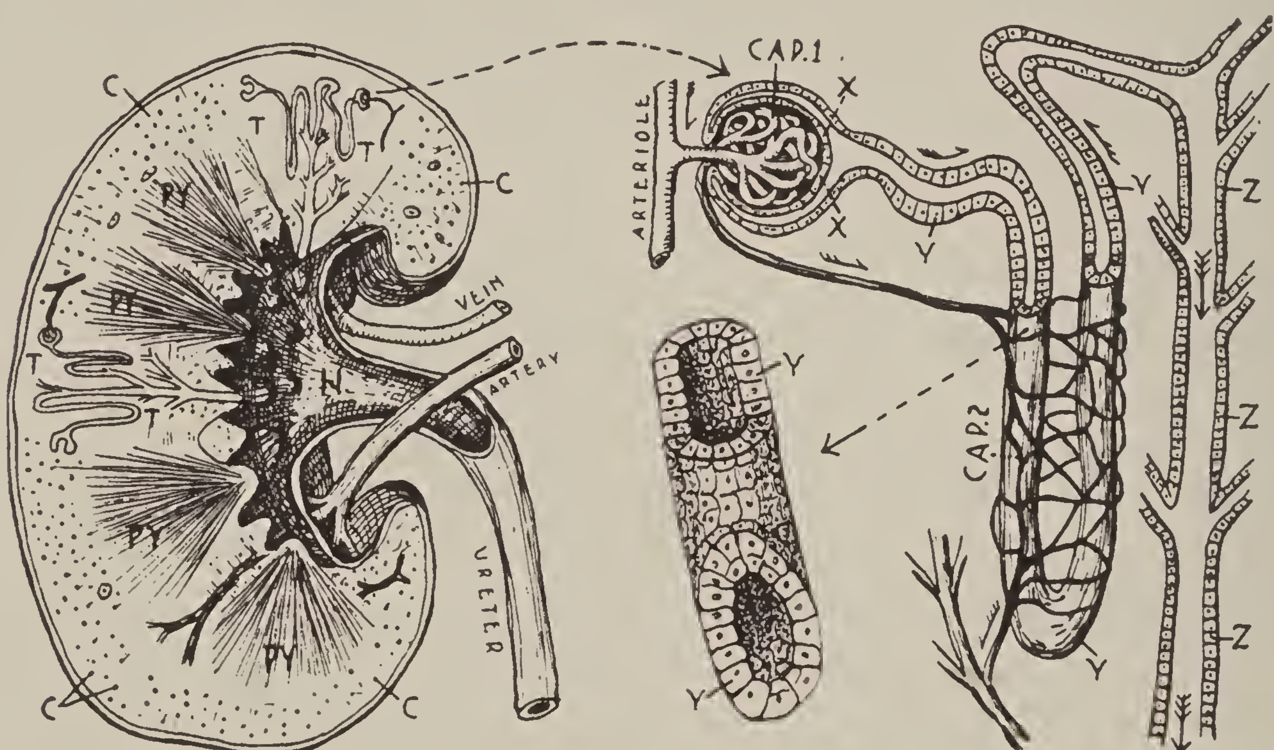


Fig. 173.—Vertical section of a kidney; H, hollow of kidney, communicating with ureter. T, tubules (much enlarged) beginning in pockets and emptying in hollow H. PY, masses of tubules beginning in pockets in region C.

Fig. 174.—Tubule and pocket of kidney, much enlarged. X, epithelial tissue of pocket, Y and Z of tubule. Cap. 1, blood capillary of pocket; Cap. 2, capillary of tubule.

Fig. 175.—A portion of tubule much more enlarged. Y, cells of tubule.

gland. By comparing Fig. 175 (a part of a tubule much magnified), with the gland shown in Fig. 118, you may easily see how much the tubule of the kidney is like a gland. We have here another example of the close relation of working cells to the blood capillaries. The waste substances here removed by the kidney cells are emptied into the hollow

of the kidney at H, Fig. 173, thence through the ureter into the bladder.

Hygiene of the Kidneys.—There are not many points to be remembered in the hygiene of the kidneys. It is likely that a large percentage of the kidney diseases which occur are due indirctly to the germ diseases like scarlet fever and smallpox. The kidneys have to filter out the poisons which the germs form in our bodies, and this work is damaging to the kidney cells (X, Y, Z, Fig. 173). The best way to take care of the kidneys is to take care of the body itself.

It is wise to drink a great deal of water at all times, as this dilutes the poisons which are thrown off by the kidneys. It seems reasonable to believe that all irritating substances which pass out through the kidneys, such as alcohol, the oils from hot condiments and spices, like mustard or horse radish, would also irritate the kidneys, and, in the long run, damage them. Fried food contains certain irritating substances which are the result of the burning of the grease, and these substances must be thrown off by the kidneys; hence fried foods are burdensome to the kidneys. Lastly, sudden and extreme changes in temperature may injure the kidneys.

Summary.

The pair of kidneys are the chief excretory organs of the body for the removal of uric waste. They are richly supplied with blood vessels. A study of the finer structure of the kidneys shows them to be true glands, for the capillaries of the blood enter pockets of gland tissue and surround tubules of the same kind of tissue. The gland cells take the waste material out of the blood and pass it on to larger tubes emptying into the hollow of the kidney. Alcohol and

toxins of disease germs are especially injurious to the gland cells of these organs.

THE SKIN.

Description of the Skin.—The skin is a double covering of the body. The thinner outer skin, the **epidermis** (Fig. 176), is

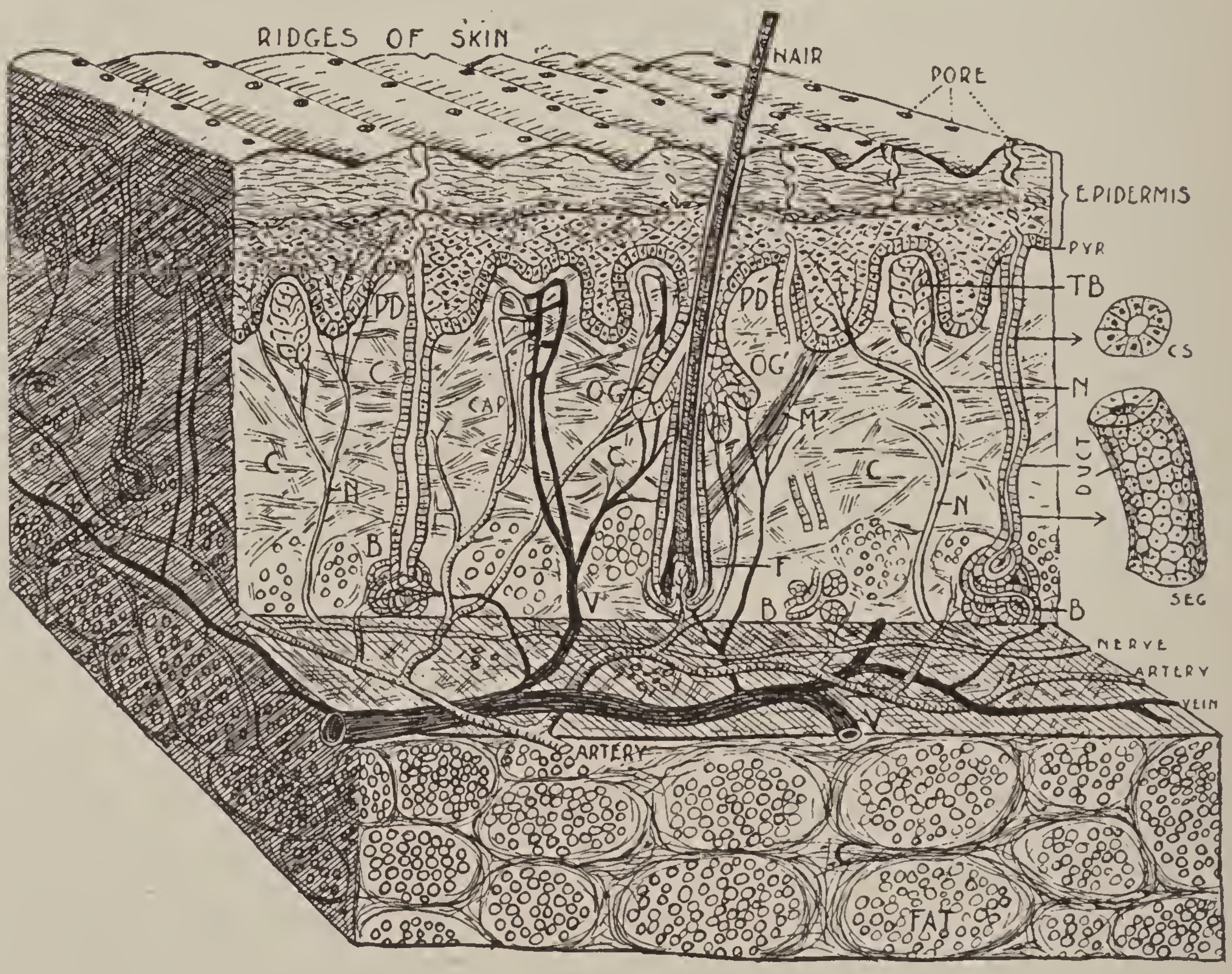


Fig. 176.—A block of skin about the size of a small grain of corn magnified. Pyr, living layer of epidermis. Below this layer is dermis. PD, papillae of dermis. TB, touch bud in papilla; N, nerve; CAP, blood capillary. B, coil of sweat glands; EG, portion of duct of sweat gland, more enlarged; CS, cross-section of sweat duct; F, hair follicle; OG, oil glands; M, muscle of hair; C, connective tissue of dermis.

made up of horny cells, with the exception of the lowest layer. This layer (PYR) produces all of the others as fast as these

are ordinarily worn away. The epidermis contains few nerves and no blood vessels. The inner or true skin, the **dermis,** is made largely of connective tissue (C); this is, therefore, the part of the skin of animals that is made into leather. It is richly supplied with blood vessels, and there are many fat cells scattered through it. The fat helps to keep animals warm; the whale, for example, has a thick layer of fat under the skin so as to keep warm in the icy waters of the cold seas. Some nerves end in certain cells placed where the dermis projects up into the epidermis; these projections, or papillae, contain the nerves of touch (N), with which we feel things, that is, distinguish hard and soft, wet and dry, sharp and dull, etc. With other nerves in the skin we distinguish heat and cold. The blood vessels are present to perform their usual duty of serving the wants of the living cells. They must, in the first place, bring material with which the living layer of epidermis can grow and multiply and produce more cells to take the place of those worn off. The mass of cells worn off in the course of a year, if they could be collected, would fill a basket of considerable size. Dandruff is simply masses of skin cells from the scalp. To furnish materials to renew the worn-off cells, the blood comes through the dermis close to the living layer of the epidermis. (Cap, Fig. 176; also C, Fig. 228.) The blood also carries material for other organs, the hair and the sweat glands, that reach down from the epidermis into the dermis.

The Hair.—The hair is horny, like the epidermis; in fact, it is produced by epidermal cells that extend down into the dermis like a kind of socket. In this socket, called the **hair follicle** (Fig. 176), the hair stands. At the bottom of the follicle is a mass of cells that grow and multiply rapidly, adding to the hair, pushing it out as it grows. Hair thus grows from the

bottom, or "root," which is richly supplied with blood. Hair has attached to it two organs; first, a **muscle** (M), which by contracting, can make the hair stand on end. A dog or a cat uses these at will, making the hairs on its back "bristle up" when angry. The other organ in connection with the hair is one or more **oil glands** (OG), which empty oil into the hair follicle. You have noticed how a leather harness cracks and breaks when not kept oiled; the skin and hair, too, must be oiled to keep them fresh and pliable.

The finger nails and the toe nails are also horny like the epidermis, but unusually thick. They are produced from cells at the base or root of the nail, and are pushed forward as they grow. (Fig. 177.) The nails should be trimmed even with the fingers, but no further. Dirt that collects under the nail should be removed with a dull instrument, not with a sharp knife, for this roughens the under surface of the nail and makes dirt gather still more easily. Stains on the surface may often be removed with vinegar.

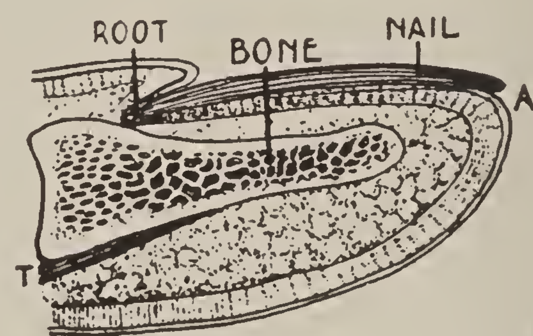


Fig. 177.—Longitudinal section of end-joint of finger.

The Sweat Glands.—Other extremely important organs of the skin are the sweat glands. These are simply tubes running down from the surface, through the epidermis, and for some distance into the dermis. They are coiled up at their lower ends. The coil (B, Fig. 176) is surrounded by a network of blood capillaries, as is seen in diagram 5, Fig. 117, and again in Fig. 178. The epithelial tissue of the sweat gland comes in close contact with blood capillaries, as is the case with all glands. The sweat gland is coiled up in the dermis (B) because

it is so long; there would not be room in the skin if all the sweat glands were stretched out straight.

The sweat glands remove from the blood sweat or perspiration, which consists of water with salt and a little waste substances dissolved in it. They are thus in part excretory, and each sweat gland may be compared to a single tubule of the kidney. (Compare SEG., Fig. 176, with Fig. 175.) How are they alike in structure? But excretion is not the chief function of the sweat glands, for the perspiration is of great use to the body in helping to keep it from getting too hot, as will be explained below. Each gland* opens on the surface of the skin by a pore. (Fig. 176.)

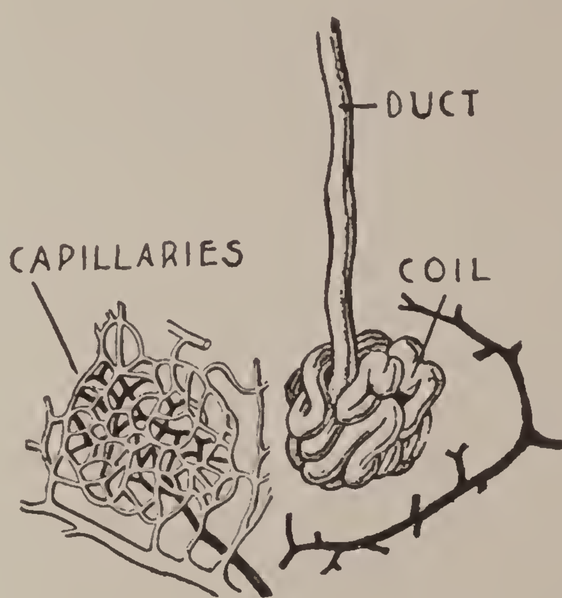


Fig. 178.—Coiled end of sweat gland; the network of capillaries removed from its natural position around the coil. Compare with 5, Fig. 117 and B, Fig. 176.

Hygiene of the Skin.—Cleanliness requires frequent washing of the skin. There are removed from the skin dirt, disease germs, the solid parts dissolved in sweat, dead epidermal cells and oils. Soap should be used in washing, for soap dissolves oil by emulsifying it, as has been already described.

Disease germs cannot easily get into the blood through the unbroken skin. Hookworm larvae on the bare feet of children get into the blood vessels of the dermis by way of the hair follicles. Lockjaw germs usually live in the soil, especi-

*The number of sweat glands has been estimated at 2,500,000.

ally around horse lots, but may, if present on the skin, be driven into and under the skin with a nail (Fig. 257) or piece of fire-cracker, or a cap of a toy pistol, and a person may have lock-jaw and die. If you wound the skin and the blood runs freely and then dries nicely over the wound, remove the excess of blood with a dry clean cloth and tie the wound up without washing, for blood itself is a good cleanser. But if the wound is open, and dirt and bacteria are apt to get in, the wound should be washed with a disinfecting solution and bound up in a clean white cloth.

Oftentimes you have noticed on the skin little tumors known as **warts or moles.** The warts are usually only temporary and harmless. The moles are usually harmless also, but may last a lifetime. Either mole or wart may degenerate or change into a dangerous tumor like a cancer, especially if it be in an exposed place where it is subject to irritation. For this reason these moles should not be allowed to become irritated. If they are in a place where irritation cannot be prevented, they should be thoroughly removed by a physician. Any sign of inflammation in a mole should be heeded, as it sometimes takes on a rapid growth.

All young people are interested in having a good complexion, and without doubt **pimples** on the face are the commonest cause of poor complexions. We do not know all of the facts as to the cause of these pimples, and until we do, we cannot do much toward preventing them. After the pimples appear, they are usually slow and stubborn to leave; but patience and care will drive them away. The problem of how to get rid of them is too difficult to explain here, but it is best to make it a rule to do two things: first, get the entire body in as perfect health as possible, and, second, do not try any plans of cure except those recommended by people in whom you have confidence.

Summary.

The skin consists of a thin horny outer layer, the epidermis, and a thicker inner layer, the dermis. The dermis is richly supplied with blood vessels which supply the sweat glands and the growing cells of the epidermis, the hair and other organs of the skin. The functions of the skin may be summarized as follows:

1. To form the covering for the body. (Both layers).
2. To protect the more delicate parts (a) from injury; (b) from disease germs. (Epidermis, hair and nails.)
3. To excrete waste. (Sweat glands.)
4. To cool the body. (Sweat glands.)
5. To act as the organ of touch. (Touch buds and nerves.)

Questions.

1. Why do the cells of the body form waste substances? 2. Name the two chief kinds of waste substances produced and the organs that remove them from the blood. 3. Why has the renal vein purer blood than the renal artery? 4. What cells in Fig. 174 take wastes out of the blood? 5. In what regard are the pocket and tubule (Fig. 174) like glands shown in Fig. 117? 6. What are the functions of the skin? 7. Name the organs found in the skin. 8. What letters in Fig. 176 refer to the living cells of the epidermis? 9. Wherein do the dermis and epidermis differ? 10. With Fig. 176 before you, describe the skin. 11. Describe a hair. 12. Why do blood capillaries come close to the root of the hair? 13. To what part of a kidney does SEG, Fig. 176, correspond? 14. Wherein are the tubule of a kidney and a sweat gland alike? 15. Why may warts or moles become dangerous? 16. How should we treat an open wound in the skin? 17. A closed wound, as a nail thrust?

CHAPTER XXXIV.

The Regulation of Heat in the Body.

If you take the temperature of a healthy person with a thermometer, winter or summer, day or night, at rest or at work, you will find it always to be practically the same, about 98½ degrees Fahrenheit. How this engine, the human body, is kept from growing cold or getting too hot we shall discuss in this chapter.

The cause of heat in the body has been touched on a number of times in this book. If not fully understood, reference should be made to the chapters dealing with oxidation, foods, respiration and kindred topics. This should be reviewed thoroughly.

Distribution of Heat in the Body.—Exercising one part of the body causes all parts to be made warmer. For example, if you work the right arm forcibly on a warm day you will soon feel warm all over. If the extra amount of heat is produced only in the arm, why does the arm not become hot? Why do all parts of the body feel warmer? The blood distributes heat over the body, drawing it away from the part being exercised. **So the blood carries away from the cells not only waste material, but also heat.**

It is now easy to answer the question, "What does the blood do with the heat brought away from the muscle cells?" The heat is carried to the skin, where the body comes in contact with the outside world. Here the heat leaves the body by radiation into the surrounding air. This occurs all the time, but faster in cold weather. In winter, therefore, more heat must be generated by oxidation; for that reason it is well to

eat more fats in the cold season. Alcohol will not do at all to produce heat in the body, as it is only partially oxidized, leaving the body through the lungs, skin and kidneys and injuring those organs as it goes.

How the Body Gets Rid of Excessive Heat.—During exercise the body must use special means of getting rid of excessive heat. Note the color of the faces of boys and girls coming in after recess from a frolic on the playgrounds. Their faces are flushed because there is more blood in the skin. The blood brings the heat to the surface to be radiated away. This is brought about in the following manner:

In all arteries, and so in those of the skin, there are muscles and nerves. When the muscles contract the artery is smaller and contains less blood. When they relax, the artery is dilated (made larger), and more blood rushes into the blood vessel. Heat stimulates the nerves that make the arteries expand. Therefore, when the body is warm the skin is red.

In case there is much heat to be removed another thing happens: the sweat glands begin to work faster, stimulated by the nerves and by the presence of warm blood around them. Sweat is poured onto the surface of the body, and there evaporates, carrying away much heat. For when water evaporates it absorbs heat, as can be seen by either of the following experiments:

Experiments.—(1) Take two thermometers. Set one into a vessel of water. Around the bulb of the other tie a rag wet with water out of the vessel in which the first thermometer is standing. Now fan the thermometers and note the drop in temperature of the one with the wet rag. (2) If the thermometers are not available, tie a dry handkerchief about one hand and a wet one about the other. Wave both through the air vigorously! Which feels the colder, and why? Tell why a person feels colder in wet than in dry clothes.

In case of fever, the body becomes hot, partly because the sweat glands fail to do their duty. The temperature of the body in fever rises above 98 1-2 degrees Fahrenheit.

How the Heat of the Body Is Retained.—We have just learned how the body gets rid of extra heat. In cold weather it is necessary to prevent loss of heat, for too low a temperature is as dangerous to health as too high a temperature.

If you recognize the fact that cold makes the arteries of the skin contract, you will readily understand Nature's way of keeping necessary heat in the body: just the opposite way of getting rid of it, namely by driving the blood out of the skin into the body and away from the cold. The less blood brought to the skin, the less heat will radiate from it.

Catching Colds.—But keeping the blood out of the skin is Nature's safeguard only within limits. You must know that the skin is a large organ and may hold much blood. This is driven out of the skin by cold, and some of it causes congestion (crowding) of blood in the mucous membrane of the throat and other internal organs. Finally this mucous membrane of the air passages becomes inflamed and bleeds from tiny hemorrhages. And if there are germs of cold or grippe present, they get a foothold in the body, causing disease. Without the germs one cannot catch cold, for travelers in the icy North do not have colds, since there are no sick persons to scatter germs. But, on the other hand, even if germs are present, without continued exposure, they are not likely to gain entrance into the blood. Sitting in a cold room below 65 degrees Fahrenheit, or having on wet clothing, even if only on the feet, or too little clothing by day or covering by night, are all dangerous to health.

Alcohol and Body Heat.—Alcohol is a drug that has the power of dilating the arteries of the skin, causing a rushing of

blood to the skin, as indicated by the red face of the drinker. This makes a person **feel** warm for a while, but it does not make him warm. It really makes him cool, for the presence of so much blood so near the surface of the body results in a rapid loss of heat by radiation. The feeling of warmth caused by the alcohol is a lie that alcohol tells the nerves. To take a drink of whiskey before venturing out into the cold is one of the worst things a person can do. Arctic explorers found this out from experience long ago.

Shelter.—Food and oxygen to make us warm, and well-trained blood vessels in the skin to regulate the heat are not sufficient for man: he needs also clothing and shelter. Man's life is largely spent getting food, clothing and shelter.

Fig. 179.—Girl in summer clothing.

The rooms of our houses should not only be well ventilated but also kept at the right temperature, 65-75 degrees Fahrenheit. If a school room is heated and ventilated correctly all parts of the room will be comfortable; none will be too hot or too cold, as is the case in too many schools in Texas as well as elsewhere. A room should also have moisture enough; this can be supplied by having a pan of water on the stove. The effects of sitting in a room that is too cold have been explained. If the room is too warm, the blood vessels of the skin become dilated, and on going into the cold, open air the body loses too much heat by rapid radiation.

Clothing.—What animals do you see abroad in the winter time? Frogs? Snakes? Insects? You see only birds, covered with feathers; mammals, covered with hair; and man, who uses clothing to retain the heat of the body. In warm weather

clothing serves also to protect the body from injury and from the heat and light of the sun.

Clothing depends for its power to retain heat on the fact that heat will not readily pass through dry air. Find out how an ice box (used to keep heat out) or a fireless cooker (used to keep heat in) are made, and you will learn how clothing keeps one warm. Furs have more air than hair. When a horse or a cow gets wet in winter it freezes much, for in that case water takes the place of air in their fur. Fur is the best material for clothing to keep one warm in extremely cold climates. Of wool, silk, cotton and linen cloth, wool is the best for winter and linen for summer wear, for wool has the most and linen the least air in the meshes of the fibers. Clothing should not fit too tightly, for in that case circulation is cut off and the body's heat cannot be well distributed.

Fig. 180.—Girl in winter clothing.

Clothing for the Climate of Texas.—In Texas a great many "northers" sweep down, causing sudden drops in temperature. When it becomes suddenly colder we should change clothing to suit the change in the weather. Many persons change to flannel or other kind of heavy underwear in the fall and wear this all winter, regardless of the weather. This is not the best plan to follow. It is best to have at least three weights of underwear to wear at different times. If one is already wearing heavy underwear and the weather suddenly becomes colder he could double the underwear, using a light weight underneath a layer of heavy underwear. Some persons find that they catch cold in changing to light underwear in the spring, but this is usually due to the too great difference in the thickness of the underwear. A good rule to follow in

changing from winter to summer underwear is to have a medium weight of winter underwear, or two thicknesses of summer underwear, so as to make the change more gradually. These and many other rules of health that stand the test today, were well known to Benjamin Franklin, who was a keen observer as well as a great statesman.

Our long hot summers can be made much more pleasant for us by wearing light, washable outer clothing. Suits of duck, cottonade, mohair and the like are light and cool, and when worn all summer enable us to endure the warmth of the climate better. It is to be noted also that light colored clothing is, in the sunshine, cooler than dark colored clothing of the same material.

Fig. 181.—A paper towel is torn off, used and thrown away.

Bathing.—In your study of the skin you learned that various secretions are poured upon the surface of the skin by the sweat glands and the oil glands. You also learned that disease germs are likely to be present in dust and dirt that gather on the skin. From a standpoint of preventing disease, the fingers are of especial importance and should be washed thoroughly with soap and rinsed off with clean water as often as the hands are soiled. Of course, all door knobs are soiled at all times, hence the fingers and hands should be washed well with soap before each meal. It is wise to keep the fingers from touching articles of food, even such as apples. The hands should always be washed after touching the body or clothing of anyone that is sick. Avoid using the common towel at public places; use the paper towel wherever supplied. (Fig. 181.)

Up to this time most households are supplied with bath tubs

instead of shower baths. This has been due to the fact that the advantages of the shower have not been realized, and also to the fact that home makers have not known a practical way to install a shower bath in an ordinary room with a pine floor. Fig. 182 shows a simple and cheap shower bath that can be substituted for a bath tub in an ordinary bath room. Under the shower is a porcelain basin and the water runs into this after trickling off the bather. A curtain is provided to keep the water from splashing on the wall or floor. This shower bath is more sanitary than the tub bath.

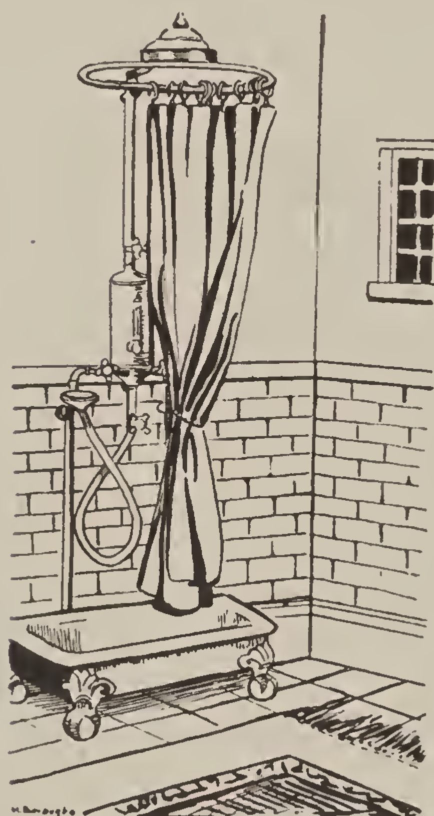


Fig. 182.—A shower bath is the most sanitary, because the water runs off of the body and away.

Hot and Cold Baths.—Besides cleanliness, there are other effects of bathing, due to the temperature of the water. Cold baths are said to make a person feel energetic and should be taken in the morning; hot baths make a person feel sluggish and tired, and should be taken at bedtime, if at all. It is always unwise to take a bath soon after a meal or to bathe when one is tired. Those who play tennis or other games until they are almost exhausted and then take a bath will find that both the exercise and the bath do them more harm than good. In the morning, or after a nap in the afternoon, is about the best time to take a bath.

Since people often go to extremes on the subject of bathing, a **word of caution** is necessary concerning the temperature of the bath water. It may be said that water about the tempera-

ture of the body is always a safe temperature. Water should not be used much warmer than this unless for some special reason, and under the advice of a physician. The water may be cooler, or even quite cold, so long as it leaves a pleasant after-effect on the bather. This applies to those who are well and strong. No one who is at all sick should take cold baths except under the direction of a physician. It is not unusual to read in a newspaper that some man has been found dead in a bath tub. This shows that the bath has so much effect on anyone of delicate health that some judgment should be used in this matter. Nervous people who are weakly and dislike the shock of the tub bath can get along about as well with a sponge bath.

Hot Applications.—The curative value of **hot applications** should be pointed out. When a person sprains an ankle or a wrist nature tries to cure the part by starting an inflammation there; the part becomes hot and red. This is Nature's way of rushing blood to the part to effect a cure. Wrists and ankles have few blood vessels in them, for there is not room for many. We can assist nature and help the circulation by applying hot cloths to the injured part. Whenever blood is wanted at a part of the body apply hot cloths; if there is a congestion, blood should be withdrawn by the application of cold water or ice to the congested part or heat to a distant part.

Ventilation of the Bath Room.—Bath rooms should be ventilated. When gas burners are used to heat the water great care should be taken to prevent suffocation from escaping gas. The heaters should have a hood and flue to carry off to the outside the carbon dioxide and other poisonous gases that result from the burning of fuel gas.

Summary.

The body is kept warm by the oxidation of the food and tissues. Fats are the best fuel food and are relished in cold weather. Alcohol is doubly harmful in the cold. The body must be kept at a constant temperature of 98 1-2 degrees Fahrenheit. Excessive heat is lost by radiation, which is greater when the amount of blood in the skin is greater, as during exercise or after drinking alcohol. Excessive amounts are removed by the evaporation of sweat. In cold weather the skin has less blood, and radiation is lessened. When the skin is cold for a long period one is likely to become sick with colds, grippe, etc. Further loss of heat is prevented by the use of extra clothing when out of doors, and by keeping the living rooms comfortable when remaining indoors. One should wear clothing to suit the climate and the weather. Bathing is necessary for cleanliness. Excessively hot or cold baths should be indulged in with judgment and only in case the after-effects prove to be agreeable.

Questions.

1. What are the functions of the skin? 2. How is bodily heat produced? 3. What becomes of the heat produced in a working muscle? 4. What is the effect of heat on the arteries of the skin? Of cold? 5. Is much or little heat lost when there is much blood in the skin? Why? 6. Why is the skin red when we are exercising? 7. Why is the skin pale when cold? 8. Why does a person actually cool off faster after drinking alcohol? 9. What are the harmful effects of prolonged chilling of the skin? 10. Why is too warm a room harmful to a person? 11. Mention some helpful points with regard to clothing for Texas climate. 12. What is the best time to take a bath? 13. When should a person not take a bath? Why? 14. Why is a shower bath more hygienic than a tub bath? 15. How would you treat a sprain?

CHAPTER XXXV.

Locomotion—Bones and Joints.

There has already been occasion to refer to various tissues or collections of cells having particular duties to perform. Thus glands, mucous membrane, epidermis, are made largely of epithelial tissue. What are the shapes of the cells of this tissue? Muscle tissue is made of muscle fibers, long cells having the power to contract, thus producing motion. Muscle tissue is bound together by connective tissues to form a muscle. Wherever in the body a long, strong, flexible cord is needed it is made of connective tissue. Thus the valves of the heart and of the veins are made largely of connective tissue. Muscles are attached to bones by strands of connective tissue called **tendons,** and bones are bound to each other by similar strands called **ligaments. Connective tissue is thus an important supporting tissue of the body.**

Cartilage tissue (or gristle), Fig. 136, has also been described. **It is also a supporting tissue** used for the framework of the trachea, wind-pipe and bronchi, the outer ear and the nose. Many bones have at their ends cartilage caps; for these caps must be **smooth,** so as to glide upon each other with little friction, and **tough,** so as not to break when struck together. Cartilage performs an important duty as a packing between the vertebrae of the backbone, for, being elastic, it helps deaden jars that might otherwise injure the brain.

Observation Work.—(1) Secure a butcher's specimen of the end of a muscle with the tendon still attached to the bone. Study all that can be made out from the specimen. Ligaments are best studied below with joints. (2) Measure your height accurately at bedtime; again on rising the following morning. What do the results prove about the cartilage between the vertebrae of the backbone?

Uses of Bones.—With cartilage and connective tissue alone, however, the body would lack the support and rigidity required. This support is furnished to the body by means of **bones,** two hundred six in number, of many shapes and sizes, all fastened together into a system called the **skeleton.** (Fig. 183.) The skeleton gives the general shape to the body. With muscles fastened to this and all covered by the skin, the shape of the body is completed.

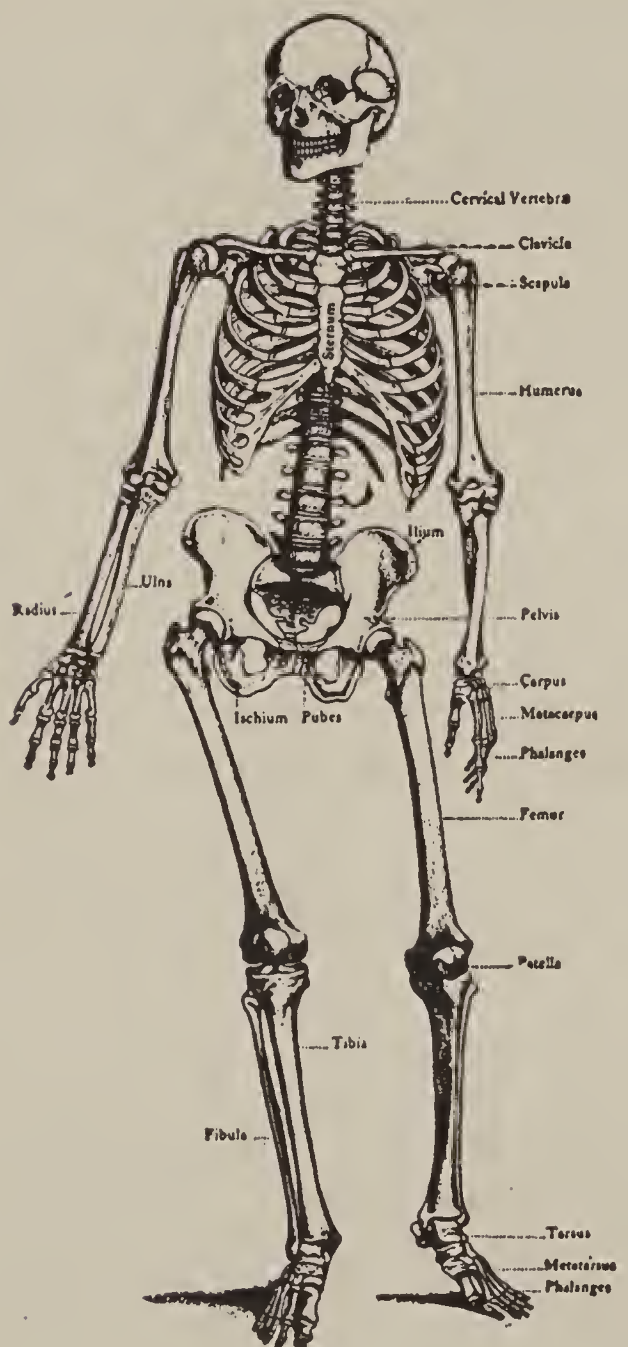


Fig. 183.—The human skeleton.

Bones act as organs of support in two special ways. The most vital organs of the body (most of the sepcial organs we have studied) are located in cavities inside the body whereby they are **protected by bony boxes.** The skull is such a box, with its flat bones "dovetailed" together into tight joints. (Fig. 80.) The spinal cord lies in a tube made by hollows of the vertebrae. (Fig. 184.) The patella, or knee-cap, protects the deli-

cate knee joint from injury. The heart and lungs are located in the chest. Such protecting bones are mainly flat bones with red marrow, as you can see by studying, for example, the sawed end of a rib secured from the butcher. This red marrow is of special interest because therein are manufactured most of the red corpuscles. There are, however, many flat or irregular bones with red marrow that serve other purposes than for protection; for example, the shoulder blades and the hip bones.

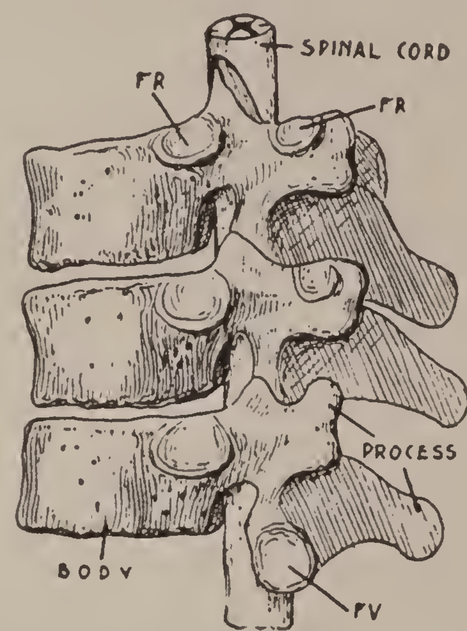


Fig. 184.—Three vertebrae with portion of spinal cord in place. FR, hollows for attachment of ribs; FV, surface for attachment of next lower vertebra.

Besides serving as support to the body, **bones are used as levers in connection with muscles to give motion to parts of the body.** Many flat bones are movable to some extent, the lower jaw and the shoulder blade being good examples. The vertebrae may move upon each other slightly, enabling us to lean the body in any direction. The bones of the hand and wrist are short and irregular bones, with red marrow, and, of course, are movable. But for rapid and powerful motion there are certain long bones of the limbs (Fig. 183 and Fig. 185) with their muscles to move them. These are light, being hollow, and of sufficient thickness to do their work. The femur or thigh bone is an example of such a long bone. It is enlarged at both ends, where it joins other bones, and has projections to which muscles are attached. Inside, the enlarged end of the bone has a spongy appearance, that is, it is full of hollows irregularly scattered among the bone tissue. (ST., Fig. 189.) But

the long, smooth stretch of bone between the enlarged ends, the shaft, consists of compact tissue, with a continuous hollow, the marrow cavity (Fig. 189), filled with a fatty marrow.

Joints.—The place where two bones are joined together is called a joint. Some joints, as those of the skull or that between the sacrum and the innominate bones at the pelvis are immovable. The vertebrae are very slightly movable, one upon the other, by the compression of the elastic cartilages between them. The bones of the wrist and ankle glide over one another; their joints are therefore called **gliding joints.** The elbow and the knee joints allow a greater freedom of motion to the arms and the legs, which move like a hinged door; they are called **hinge joints** (Fig. 198). Still greater freedom of motion is enjoyed by the upper arm, which is attached to the shoulder blade by a **ball and socket joint,** allowing the arm to be moved in almost any direction. By a similar joint, but by a deeper socket, the femur is attached to the innominate or hip bone. At the elbow there are two joints: the ulna is attached to the humerus by a hinge joint, the radius by a **pivot joint,** which allows the latter bone to twist around and enables us to turn the hand palm up or palm down (Fig. 185), in a way in which we cannot turn the foot. Study other joints in your own

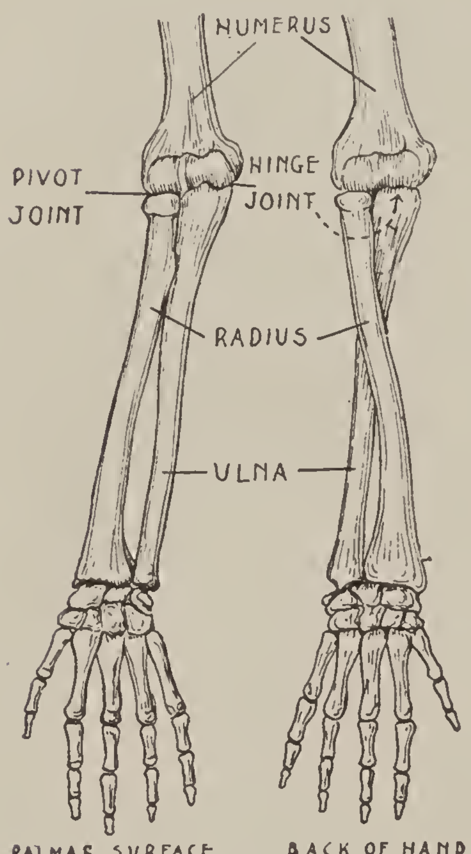


Fig. 185.—Diagrams, showing how the hand may be turned around by means of the pivot joint of the radius. For use of hinge joint see Fig. 193.

body and try to tell what kind of joint each is. A joint is a wonderful piece of mechanism. Cartilage covers the enlarged end of the bone, thus affording a smooth surface. To reduce friction still further, there is in the joint a two-layered membrane (the synovium), which secretes a fluid that keeps the joint well oiled. (Compare the synovium

FIG. 186.

FIG. 187. FIG. 188.

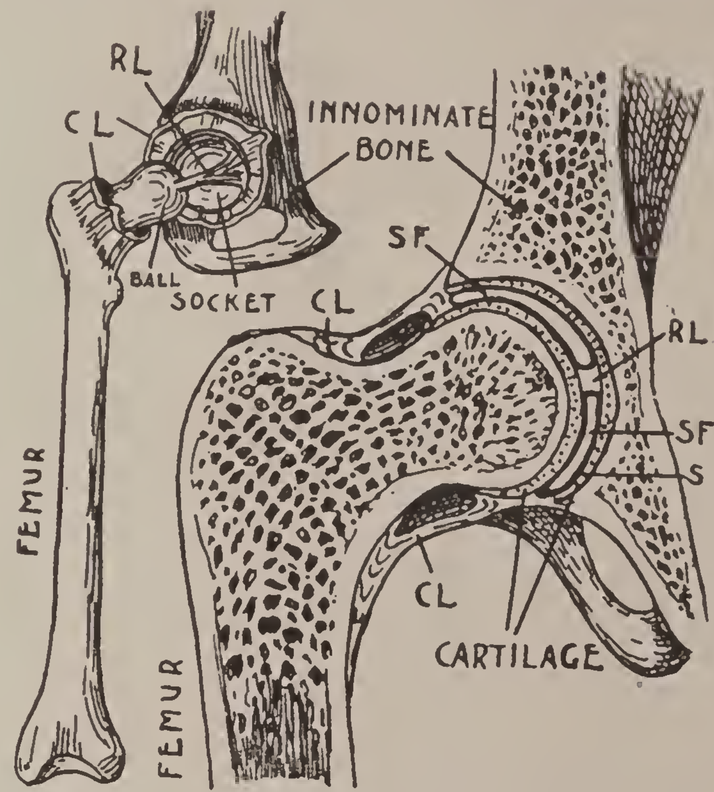


Fig. 186.—Hip joint; I, innominate bone; CL, capsular ligament.

Fig. 187.—Hip joint with capsular ligament (CL) cut to show the round ligament (RL).

Fig. 188.—Section of hip joint. CL and RL, ligaments; S, synovial membrane over cartilage of joint; SF, synovial fluid.

with the plurae and the pericardium.) The ball and socket joint is described in Figs. 186-188. There are two ligaments, the round ligament (RL) and the capsular ligament. (CL.) Further details of the joint can be studied in these pictures, and also in an actual joint of some animal.

Observation Work.—Secure a ball and socket from the butcher, first having him saw it in two lengthwise. Study the compact and the spongy parts of the bones, the smooth cartilage tip of the "ball" and the lining of the socket and the ligament.

Hygiene of Joints.—Sometimes a joint becomes dislocated or sprained, ligaments being torn loose or strained. Hot ap-

FIG. 189.

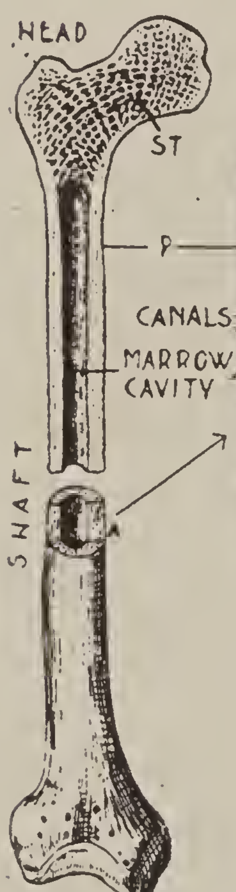


FIG. 190.

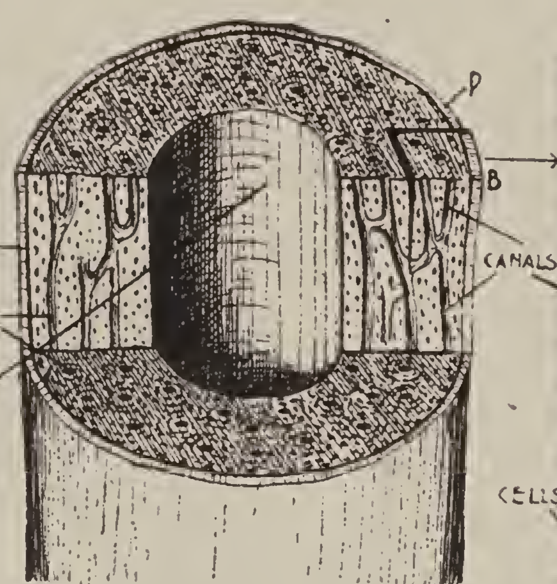


FIG. 191.

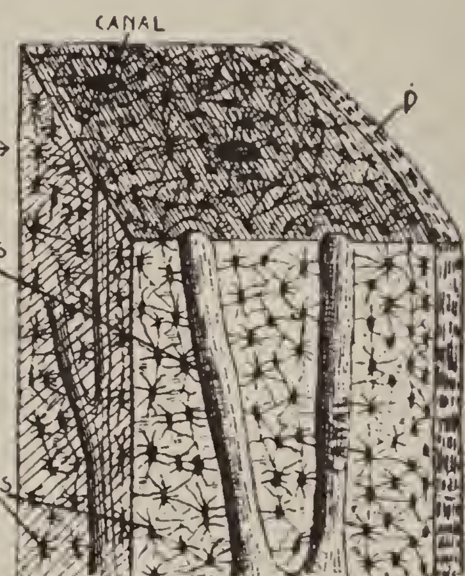


Fig. 189.—Femur, one-half in longitudinal section, showing spongy tissue (ST) in end and compact tissue around the marrow cavity in shaft. P, periosteum. Cut end, A, enlarged in Fig. 190.

Fig. 190.—End A of Fig. 189 enlarged, showing bone tissue in shaft of femur.

Fig. 191.—Bone tissue, block B of Fig. 190, still more enlarged. This shows the arrangement of bone cells (black dots) about the canals. Still finer canals run out from the cells.

plications to the sprained spot will aid nature to effect a cure. A severe sprain should receive the immediate attention of a physician.

Bone Tissue.—If you hold in your hand a cross section of a long bone, such as appears in the center of a piece of round

steak, the bone tissue seems perfectly solid and impenetrable. Under the microscope, however, it is quite different. The apparently solid part of the bone is seen to be traversed by fine canals containing blood vessels and nerves, and about these canals living bone cells are arranged as shown in Figs. 190 and 191. The cells themselves are connected with the canals and with one another by still finer tubes. Thus it is seen that even the solid part of bone is porous and supplied with blood. Figs. 189-191 should be carefully studied to make this point clear. Poisons, like alcohol and tobacco, are carried out into the bone canals to the very cells. This helps to explain why youthful users of these drugs become stunted in growth and fail to attain the full development of their bones and other organs of their bodies.

Fig. 192. — Bone tied into a knot

All bones are surrounded by the **periosteum** (P), which holds many blood vessels and nerves that pass through it on their way into the bone.

Experiments to Show the Composition of Bones.—(1) Examine a bone that has been burned thoroughly. Describe it. Compare it with pieces of limestone. It is the mineral part of the bone, made up largely of limestone and phosphate of lime. It is the part that makes bone hard. (2) Soak a bone of convenient size, say a chicken "drumstick," in strong vinegar or weak hydrochloric acid, and note the result. Tie the bone into a knot (Fig. 192). State what has been removed from the bone. What is left is "animal matter," which gives toughness and a certain amount of elasticity or "springiness" to the bones.

Hygiene of Bones.—It is of extreme importance that people recognize the fact that children's bones contain a small

proportion of mineral matter, and are, therefore soft and flexible. Since this is true, it is easy to see that children's bones are easily bent out of shape and permanently deformed. A babe may bend his legs out of shape by learning to walk too early, or by walking too much. It is important for old and young, but especially for the young, to assume an erect posture in both sitting and walking, with chest raised and shoulders thrown back. This is not only better for the bones but for the lungs and other organs, and it also improves one's personal appearance. Many persons are one-sided from always carrying articles (school books, for example,) on the same side.

FIG. 193.

FIG. 194.

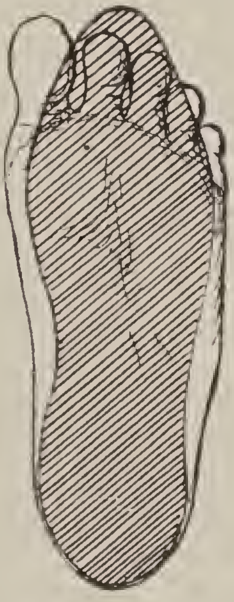


Fig. 193.—A deformed foot.

Fig. 194.—Natural shape of foot and shape of ill-fitting shoe.

Observation Work.—Measure carefully the height of each shoulder from the ground. Compare the two measurements to find out whether or not you are one-sided.

Tight clothing is especially to be condemned as unhygienic. The habit of tightly lacing the waist is very common, and is fraught with great danger to the health. The feet, too, are often abused with tight and ill-shaped shoes. Shoes should fit well and should not have high heels. There are three ways by which the skeleton helps to prevent the jarring of the brain: the elastic cartilages between the vertebrae, the curvature of the spinal column and the arched foot. (Fig. 195.)

The foot naturally acts like a spring in deadening the shock. But with high heels the foot tends to slide down into the toe of the shoe, pinching the foot still more and causing corns and other painful ailments.

Fig. 195.—Bones of foot, to show arched shape.

School Desks.—Inasmuch as young people spend a great deal of their time sitting at their desks in school, it is essential to their health that they learn to assume a correct posture and get into the habit of so doing. This is, of course, impossible where the desk is too high or the seat too low. School boards and school patrons do not always understand that it is important that desks be hygienic and that they be of the right size and shape to suit the pupils. If the seat is too low the position of the occupant is necessarily cramped. If it is too high, the feet dangle in the air, the pressure on the muscles of the thigh cuts off the circulation and the weight of the feet bends the femur out of shape. If the desk is too high the arm and shoulders are unduly raised in writing; if too low, stooping is necessary in working over the desk, and round shoulders and hollow chests result. Many schools are thus causing physical defects in children—defects that often persist through life. The ideal school desk

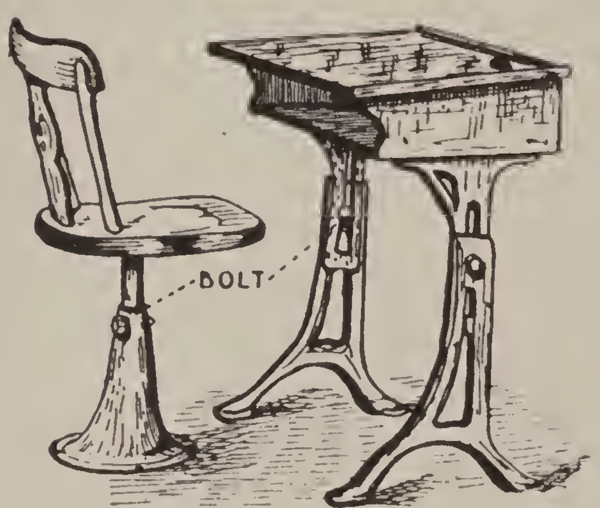


Fig. 196.—A school desk and seat adjustable to size of pupil.

is the adjustable desk. (Fig. 196.) The next best is the patent desk of the right height to suit the child. It is the duty of taxpayers and school trustees to see to it that these desks are secured. But if this is not done, the teacher can often make a child comfortable with a box as a foot rest or with some other device, or she can relieve the situation, particularly with the youngest children, by giving frequent short recesses and by dismissing early in the afternoon.

Summary.

Bones with connective tissue and cartilage form the framework of the body. Bones also protect delicate organs from injury, and, having muscles attached to them, act as levers to move the body. These two hundred or more bones of the body are of many different shapes, according to the function they perform. The long bones are hollow, so as to combine strength with lightness of weight. The flat bones contain "red marrow," where the red corpuscles are manufactured. Even the solid part of the bone is porous, being traversed by fine canals containing blood vessels and nerves. The bone cells are arranged around the canals within the bone substance. Bone tissue contains animal matter for toughness, and mineral matter for firmness.

Bones are bound together by ligaments at the joints. Smooth cartilages and synovial fluid in the joint prevent friction as the bones rub upon each other.

Mineral matter is deposited in bones throughout life. The bones of children are soft and therefore easily bent out of shape. Correct positions in sitting and standing and avoidance of tight clothing are essential to the proper growth of the bones. Anything that injures the body in general, like

alcohol, tobacco or unhygienic habits, will prevent the proper development of the bones.

Questions.

1. Name some organs of which cartilage tissue forms a part. 2. What is a tendon? 3. A ligament? 4. Point out each in two different pictures. 5. Of what kind of tissue are tendons and ligaments chiefly composed? 6. In what direction do the canals run through a long bone? 7. What are the canals for? 8. How are the bone cells arranged with reference to the canals? 9. With Figs. 189-191 before you, describe bone tissue. 10. State the use of bones. 11. Give the chief uses of each bone that may easily be seen in Fig. 183. 12. Name the kinds of joints and give examples. 13. Name the two joints in the elbow. 14. State the use of each. (Study Figs. 185 and 198.) 15. How may tobacco keep the bones from developing properly? 16. How can we prove that bones contain mineral matter? 17. Animal matter? 18. Why may children's bones be easily bent out of shape? 19. How may you develop an erect, strong framework of your body? 20. State the importance of having the right kind and size of school desk.

CHAPTER XXXVI.

Locomotion: Muscles.

Fig. 197.—The muscles.

When a boy is large in stature his size is due mainly to the size of his bones; it is his muscles that give him power to do things. When a boy wishes to show his strength he holds out his arm and says, "Feel my muscle." If the biceps of his arm is large and hard, he has strength, for the muscles can contract with much power.

Uses of Muscles.—Throughout this book reference has been made to the chief use of the muscles, namely to produce motion. Muscles are used in the digestion of food. The pylorus is a sphincter muscle whose special use is to regulate the passage of food from the stomach. A large number of muscles

are used in breathing. The tongue itself is a mass of muscles. We noted that the heart is a muscular sac, the use of which is to pump blood, and that the arteries and veins contain muscles. As long as we live there must be some motion of organs in the body. For the larger motions of the body, muscles are attached to bones. A muscle runs from bone to bone across the joint, and thus, by contraction moves one bone at an angle upon the other. (See Fig. 198.) In this way the fingers, arms, legs, etc., are moved and the whole body is carried from place to place, as in walking, running and jumping. Even in standing many muscles are in use. (Fig. 199.) About two-fifths of the weight of the body, or more than one-half of the soft parts of the body consists of muscle. (Fig. 197.) An inspection of a butcher's shop will convince one of the amount of muscle it takes to carry on the work of an animal's body.

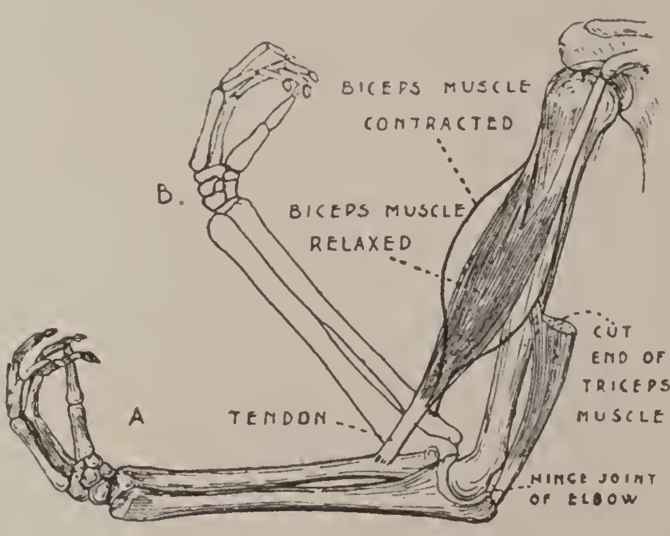


Fig. 198.—Muscles are attached to bones for the larger motions of the body.

While it is true that muscles are of use primarily for movement, they serve other purposes. The muscles of the abdominal wall protect the intestines, and the cheek forms one of the boundary walls of the mouth. Muscles, too, with the skeleton as the support and with the skin as a covering give grace of form to the body; they cover the joints and fill the cavities.

Two Kinds of Muscles.—A little reflection and experiment will show that there are two kinds of muscles. You can move

your finger, your eyelids, your arm, at will. But you cannot make your heart beat, nor stomach churn, and after you have pushed food back into your throat you cannot stop it from going down the gullet. There must therefore be two kinds of muscles according to whether they are under the control of the will or not. The muscles used in the large movements of the body, as of the limbs, are under the control of the will and are called voluntary muscles. Muscles not under the control of the will are called involuntary. Locate some involuntary muscles.

Fig. 199. — The large muscles used in standing.

There is, too, a great difference in the cells of the two kinds of muscles, as shown in Fig. 200. The cells are all long and are for that reason called fibers. The voluntary muscle cells are striped crosswise (I), and have many nuclei; the involuntary muscle cells are smooth and spindle-shaped, and have one nucleus each (III). The striped muscle fibers have to contract quickly and forcefully; the smooth fibers are slow-acting. The heart muscles are therefore an exception, in being involuntary but striped (II), for the contraction of the heart must be rapid like that of the limb muscles.

Structure of a Muscle.—Muscle fibers are connected together into a whole organ, a muscle, with connective tissue fibers, which extend all through a muscle and come out at the ends as the tendon. (Fig. 201.) The nearer the end of the muscle, therefore, that a piece of beefsteak is cut the tougher the steak, because the connective tissue is more plentiful than

muscle tissue. (Fig. 81.) The function of the tendon is to bind muscles to bones. Often the bone that is to be moved is some

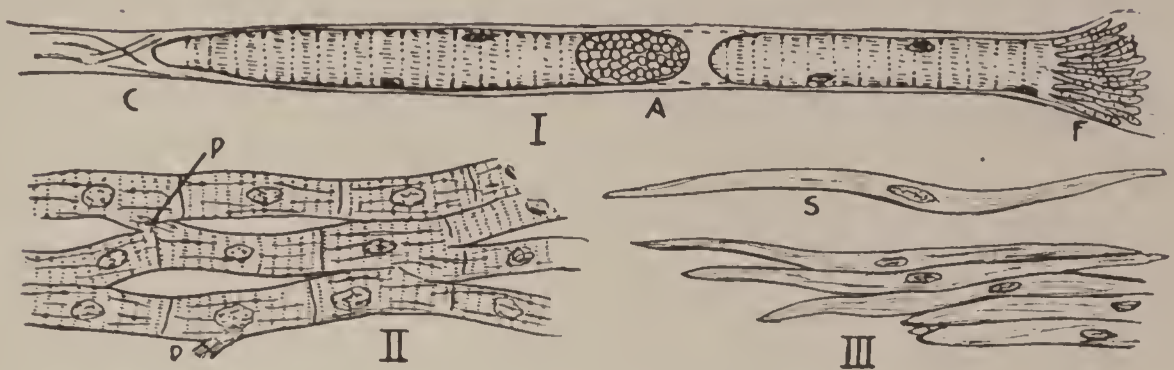


Fig. 200. Muscle fibers: I, striped, voluntary; II, striped of heart; III, smooth. C, connective tissue; A, cut ends of fibrils, better shown at F; P, process of heart muscle fibers. S, a single smooth muscle cell.

distance from the muscle that moves it; the tendons, therefore, serve to bridge over a part where there is insufficient room for muscles.

FIG. 201. FIG. 202. FIG. 203

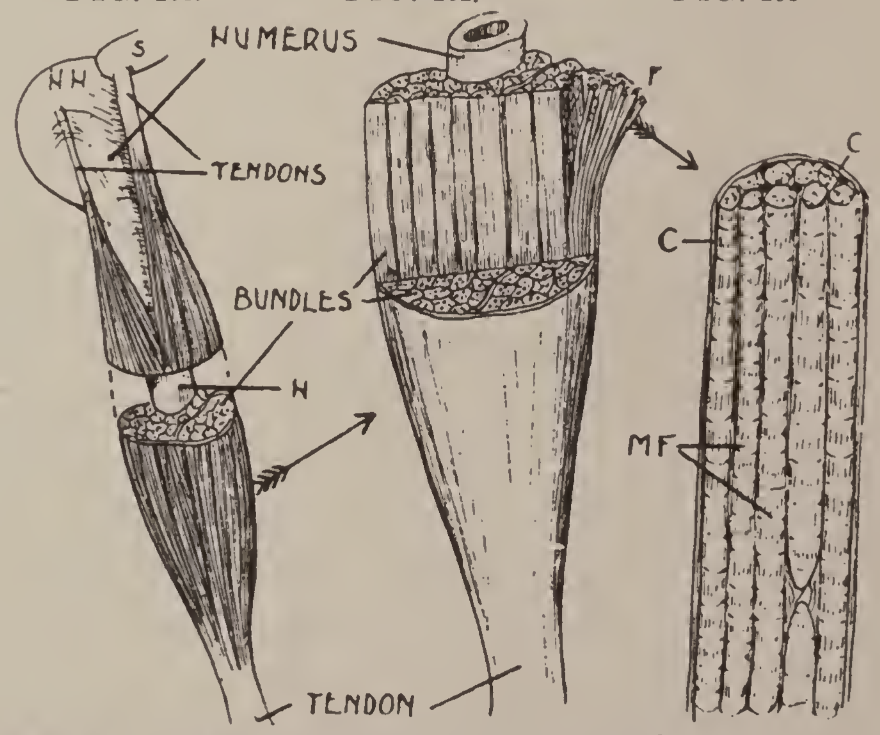


Fig. 201 to 203.—Structure of a muscle.
Fig. 201.—Biceps muscle of arm, with portion cut away exposing the bone (H). Fig. 202. Lower portion of Fig. 201 more enlarged, showing the larger bundles; F, smaller bundles within larger bundle. Fig 203, a smaller bundle containing muscle fibers (MF) bound together by connective tissue (C).

Observation Work

Study your forearm, hand and fingers for the parts mentioned above. Move your fingers freely and at the same time watch all parts of the arm and hand to determine the relation of muscles, tendons, bones, etc.

Hygiene of the Muscles.—Review page 131 and then state in your own words whence the muscles secure the energy with which to do work.

Food must necessarily be brought to the muscles to repair them as they are used and to furnish them with energy. Blood vessels course through the muscles, and the blood capillaries come close to the fibers or cells as they do to all of the cells of the body. (Fig. 204.) This is, of course, as you would expect from what you have already learned about the relation of capillaries and cells. To nourish the muscles properly food must be taken in well-balanced rations. What would you suggest as a model dinner for an athlete training for a contest? Greasy foods and pastry are not eaten by the best athletes.

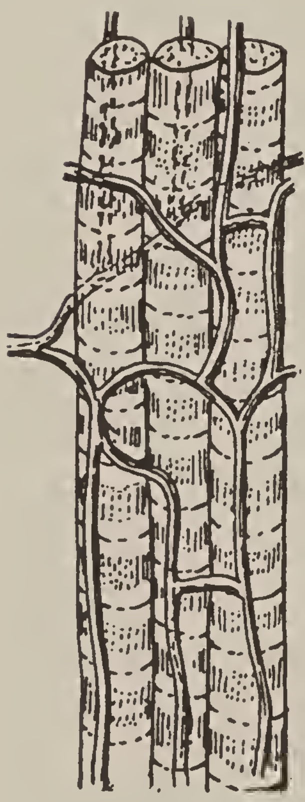


Fig. 204. Blood capillaries supplying muscle fibers.

Alcohol and tobacco are also strictly avoided by athletes, for they have uniformly found these drugs to reduce their strength. If neither of these poisons is good for an athlete, does it not seem reasonable to suppose that they are harmful to all who use them? If a boy will abstain from the drugs to win a footrace or help win a football game, does it not pay to do without them so as to have a healthy body for the battles of life? Some persons believe that they can do harder work under the stimulus of alcohol; but they are deluded in this, for experiment after experiment has proved that alcohol actually lessens the power of the muscles to contract. This is another fact which Benjamin Franklin knew from observation, and which was later proved by scientific experiment.

Fresh air, rich in oxygen, is another essential to the health of the muscles, as it is to the health of the whole body.

Exercise is absolutely essential to the health of the muscles. Its most important advantage is the effect on the circulation of the blood and lymph, as described in Chapter XXXII. The heart is made to beat faster, and is thus itself exercised; the breathing movements are increased; the veins are squeezed with each contraction of a muscle, and the blood, directed by the valves, is forced on toward the heart. All of these activities help the circulation of the blood and the lymph.

To be of greatest value to the body, exercise must be pleasant. **Play** is, therefore, an essential element in one's training. All young animals play; it is Nature's way of developing their muscles. Children should be allowed their God-given right to a reasonable amount of play. Games, moreover, develop the social instinct, teach children to work together ("team work"), to be honest, to be considerate of one another, to stand up for one's rights, and to learn human nature. Older persons should engage in outdoor sports as strenuous as circumstances will allow. Name ten good games that require some exercise out of doors.

Fig. 205. A healthful form of recreation.

Gymnastic exercises are valuable principally for the fact that with them deformities may be corrected or undeveloped muscles brought out. Exercises for almost every voluntary muscle of the body have been invented, so that a person may take a scientific course in physical culture by the gymnastic method. Gymnastic exercises usually lack interest, and are, in general,

not so good as enjoyable games. A five or ten-minute drill, with movement of the trunk and limbs, may, however, be very beneficial in school, where the pupils have to sit still so long at a time. A five-minute walk out into the open air would be better, but the weather frequently prevents this.

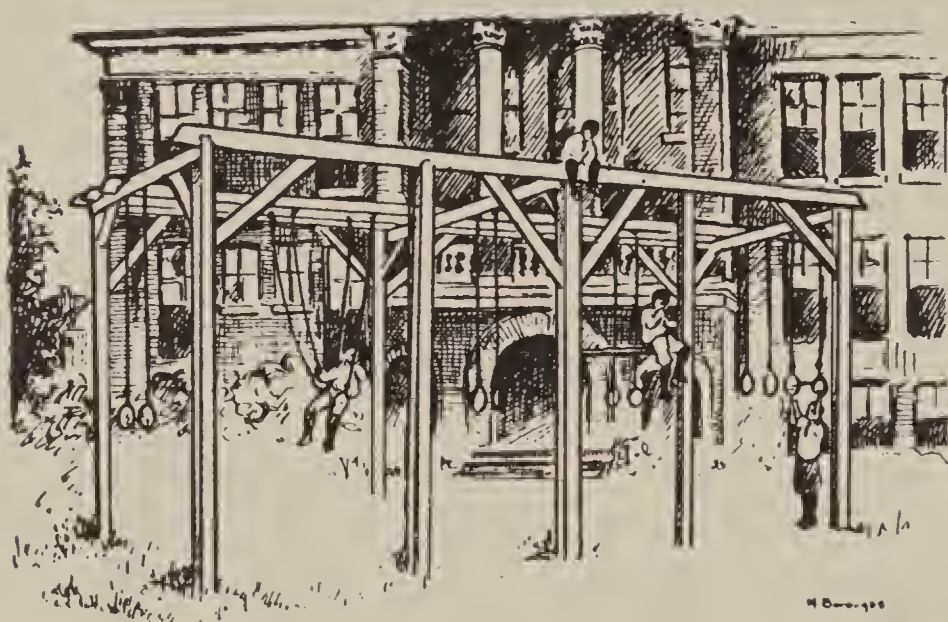


Fig. 206.—A playground is a valuable part of a school equipment.

Boys and girls need a great deal of play, but also an equal amount of good hard work. A good combination would be splitting wood, digging bait and going fishing. Some hard work is good for girls, too, for example, sweeping (but not by the dry method) and washing dishes; but, they, too, need an equal amount of play.

Fatigue.—There is a limit to the amount of exercise one ought to take. Have you ever been out on a picnic or a day's tramp and come home very tired? And did you not feel "sore" the next day, the very muscles hurting when you touched them? Why did they hurt? Study Fig. 152 and try to tell the answers. Waste products from the muscle cells themselves accumulate during continued heavy exercise faster than they can be carried off by the blood, and they act as a toxin on the cells of the body. This condition is called fatigue.

Rest.—Rest, therefore, becomes imperative. Rest gives the muscle and nerve cells a chance to get rid of waste substances and to rebuild worn-out protoplasm. During rest the building-up process is greater than that of the tearing-down. A person who does not rest sufficiently cannot do his best work, does not enjoy life fully and may finally become a prey to disease germs.

Summary.

Muscles, by contraction, cause all motion of the body. Some muscles are involuntary and are made up of smooth muscle fibers. Such muscles carry on the movement of the internal organs. The voluntary muscles, made of striped fibers, are attached to bones, and with them as levers, move the limbs. Blood capillaries supply all of the muscle fibers with food and oxygen, and carry away wastes produced in exercise. They also carry alcohol and the poisons of tobacco to the fibers, weakening the muscles.

Exercise is highly beneficial to the muscles if pleasant and enjoyable. Outdoor games are the best form of exercise, except for special purposes. We should never exercise to the point of bing "dead tired," but should stop and rest when the point of pleasant fatigue is reached.

Questions.

1. State the use of muscles. 2. Point to the biceps and the triceps muscles of your arm. 3. Place your biceps in position B, Fig. 198. 4. What joint does the lower tendon of the biceps cross? 5. Name an organ that contains muscles of the smooth kind only. 6. Describe three kinds of muscle fibers. 7. How do the muscle cells secure their nourishment (Fig. 204)? 8. Comparing Fig. 204 with Fig.

152, discuss the general activities of a muscle cell. 9. What part does connective tissue play in a muscle (C, Fig. 203)? 10. What part of Fig. 202 is the bundle shown enlarged in Fig. 203? 11. What are some of the needs of muscle cells (Fig. 152)? 12. What drugs weaken the muscles? 13. Discuss the value of exercise to the muscles. 14. What is the chief value of play? 15. Discuss the use of gymnastics. 16. Why is rest necessary? 17. How is fatigue produced?

CHAPTER XXXVII.

The Nervous System—General.

Thus far we have considered the body as being made up of myriads of separate cells, each with its own work to perform. These cells are united to form tissues, and tissues make up organs. Thus a gland is an organ made up mainly of epithelial tissue. each cell of which does its part of the work of the gland. We have considered the different organs chiefly as separate parts of the body without especially noticing how one part acts upon another. We have studied the **operation** or work of the cells, tissues and organs. In the present chapter we shall lay stress on the **co-operation** or working together of the parts of the body.

Examples of Co-operation.—Everyone is familiar with examples of the co-operation of the organs for the good of the whole body. The blood serves every cell in a very important way, as has often been pointed out. The liver does work of value to the whole body, for if it were removed death would result. Even waste substances in small amounts are of value to the body, because they cause fatigue and induce sleep. When we consider the body as made up of many co-operating parts we might liken it to a perfect baseball team, each of whose nine members does the right thing at the right time, all co-operating that the team may win.

Review Work.—Make a list of the most important organs you have studied and state what each does for the good of the whole body.

The more you think about it the more you will realize how beautifully this machine, the body, works. If some one

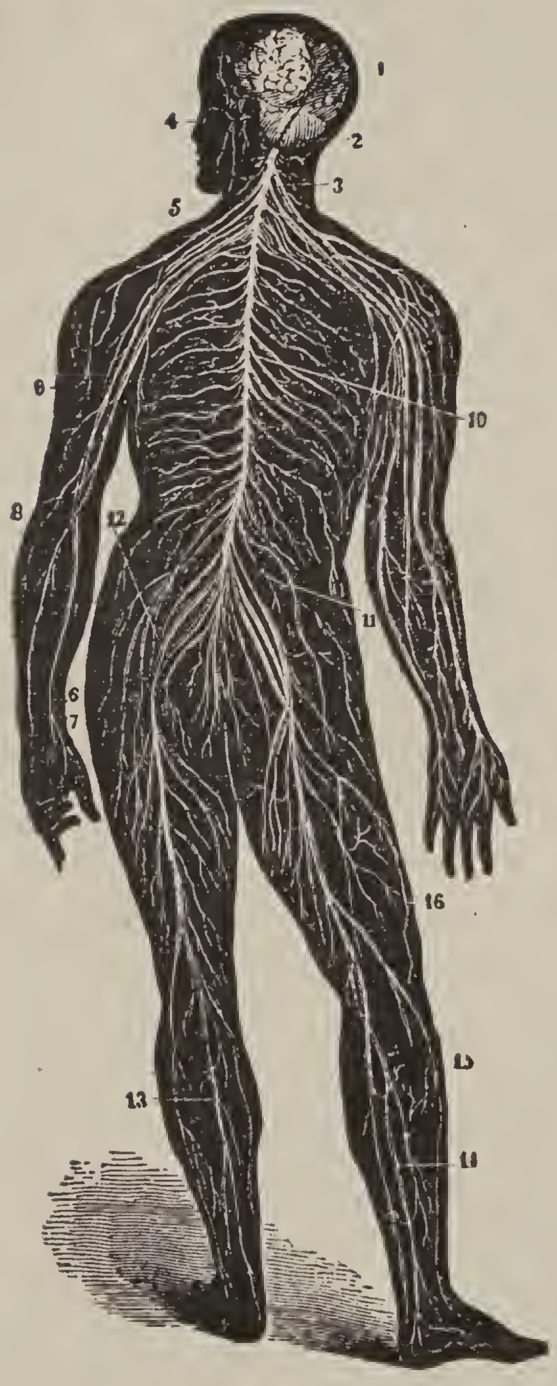


Fig. 207. The nervous system.

strikes at you, you wink your eyes, throw up your hands and perhaps step back. If a particle of food goes "the wrong way" on passing the throat (see Fig. 133) you cough; or if dust enters the nose, you sneeze. As you taste food and begin to chew, the digestive glands begin to secrete.

If you prick your finger with a pin there is a message sent to the brain and spinal cord, and in an instant a message is sent back to the proper muscle to remove the finger from the place of danger. Or, I may say, "Move your right thumb;" you hear what I say and do as I request. My voice, your ear your thumb—nature has, in a wonderful way, made means of communication among them.

Review Work.—Review pages 131 and 259 and tell at least a half dozen things that happen in as many of the organs of the body when you begin to exercise, for instance, to run. Review Chapter XXXIV and tell how heat and cold affect the blood vessels of the skin.

Nerve Cells.—Communication between parts of the body is

brought about by nerves, as every one knows. It is hardly necessary to state that the nervous system is made up of cells as is every other part of the body. A little reflection would lead us to suppose, which is actually the case, that nerve cells are longer and more slender than any other cells, even than muscle and connective tissue fibers. Fig. 208 is a diagram of a nerve cell. The body of the cell (called simply **nerve cell** for the sake of brevity) contains the nucleus and has running off from it one or more long processes and usually many short ones. The short processes are of use in communicating with adjoining cells; the long ones, the **nerve fibers,** run to the various cells of the body or to other nerve cells. The nerve fibers may be very long, these running into the feet attaining the length of a yard or more. A single nerve fiber cannot be seen by the naked eye, but when many are bundled together they form a **nerve,** and a nerve can be seen as a white strand of greater or less thickness.

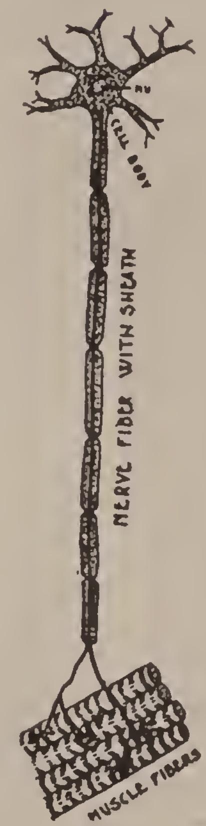


Fig. 208.—A nerve cell.

The Function of Nerves.—If you were asked what the brain is for, you would probably say, "To know and feel with," by which you would mean that the brain is the organ of the mind. If asked the function of nerves you would now readily answer that nerves carry impulses from one part of the body to another, and so keep the parts co-operating for the good of the whole. These two answers are as nearly correct as most people can state them. We might compare our system of nerves with a telephone system. The nerves correspond to the wires which connect homes, stores and offices in a city. There are, moreover, nerve centers, the brain and

the spinal cord, corresponding to the central office or exchange of the telephone system. When you wish to telephone, you first "call central," and give the number you want. Likewise, when you touch the point of a pin with your finger, a "call" is sent to the "central" of the body. Again, the central operator of the telephone gives you the number you call for and **rings** that number. So, too, in the brain or spinal cord, the message, "Sharp object at finger," is changed to "Move finger away," and this message is sent to the proper muscles of the arm and hand. There are, therefore, nerves running **in** from the skin, which bring us in touch with the outside; and there are nerves running **out** to the muscles, controlling their action.

The organs of the nervous system might be said to consist of the **central** nervous system, the brain and the spinal cord, containing most of the nerve cells; and the **peripheral** nervous system, consisting of nerves and containing mainly nerve fibers.

Summary.

The functions of the nervous system are to act as the organ of the mind and to control all the organs of the body. The nerve cells receive or send on impulses or messages, and their nerve fibers carry the impulses from one part of the body to another.

Questions.

1. Do you think the various parts of the body are independent of one another? 2. Give reasons for your answer. 3. Give examples of co-operation of organs. 4. How are parts brought into communication? 5. Wherein is the nervous system like a telephone system? 6. Name the parts of the central nervous system. 7. Of what does the peripheral nervous system consist? 8. Find these parts on Fig. 207.

CHAPTER XXXVIII.

The Brain.

Since the brain plays such an important part in the body it might be pointed out as the most important organ of the nervous system. We must bear in mind, however, that all of the parts of the nervous system are of importance. The organs of the nervous system are:

1. The brain (Fig. 209).
2. Twelve pairs of nerves arising from the brain and running out mainly to the head, shoulders and vital organs (Fig. 210).
3. The spinal cord (Fig. 210).
4. Thirty-one pairs of nerves arising from the spinal cord and sending out branches into the trunk and the limbs (Fig. 210).

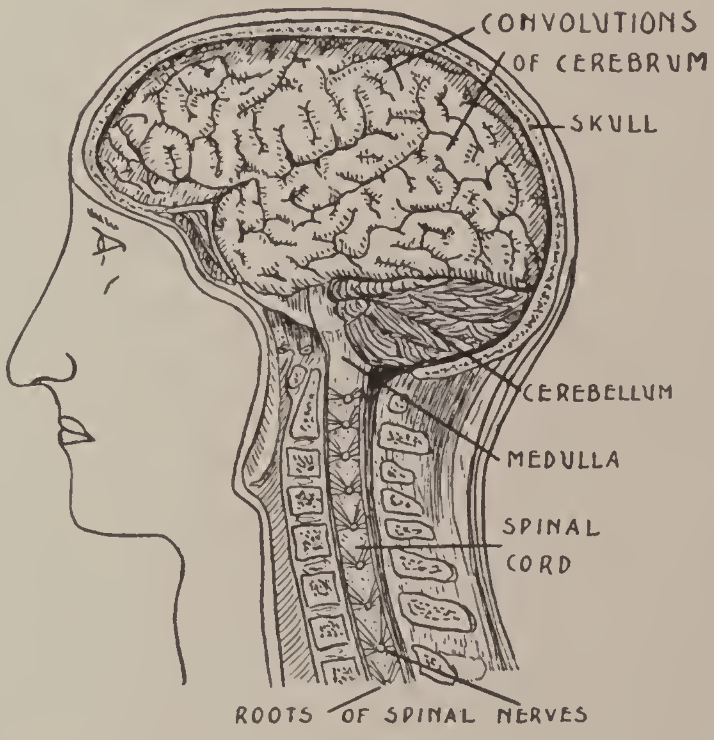


Fig. 209. The brain and upper part of the Spinal cord.

5. The sympathetic ganglia and their nerves (Fig. 210). 1 and 3 make up the central nervous system; 2 and 4 the peripheral nervous system.

The brain lies in the hollow of the skull, and the spinal cord in the canal running through the spinal column. (Figs. 79 and 207.) Besides the bony covering, both have three double protective coverings,* with all the spaces filled with lymph. So the brain and cord fit snugly into their cavities. The brain is also protected from jars by the springy arch of the foot, by the curves of the backbone and by the cushions of cartilage between vertebrae.

The Cranial Nerves—Coming off from the brain are bundles of nerve fibers. There are twelve pairs, called **cranial nerves**, that go to the head, shoulders and vital organs of the chest and abdomen; these pass through openings in the skull. One pair of these (Fig. 210) goes to the nose, and they are called the nerves of smell; another (2) to the eyes, as the nerves of sight; and one pair (8) to the ears, as the nerves of hearing. Three pairs (3, 4, 6) cause the eyeballs to move. Toothache, taste and other sensations pass up other

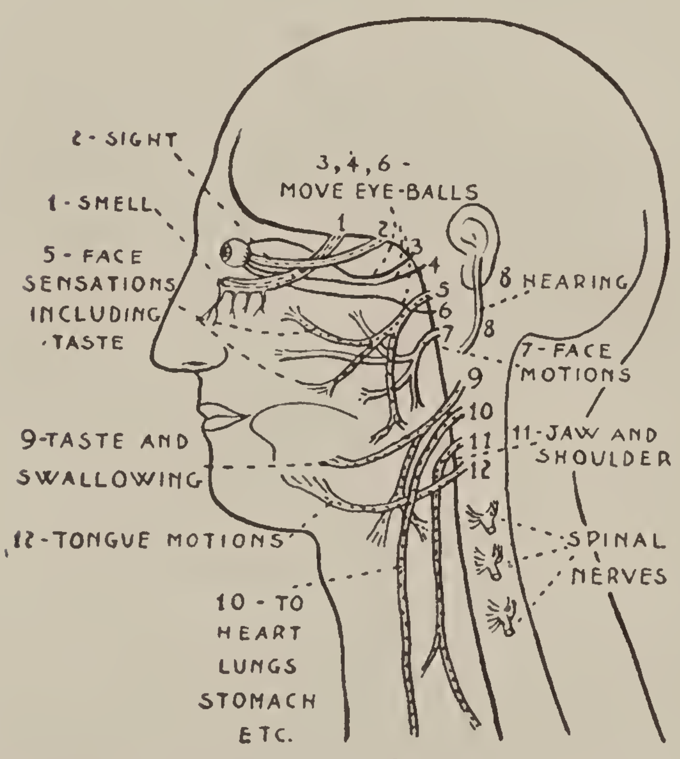


Fig. 210.—Diagram showing the twelve cranial nerves.

*The three together are called the **meninges**. (M., Fig 217.) The disease of the nervous system called **cerebro-spinal meningitis** derives its name from these membranes, which are influenced by the disease.

cranial nerves to the brain; when you laugh or cry the brain sends its commands along certain other nerves to the muscles of the face. The cranial nerve (10) going to the chest and abdomen has to do with the heart-beat, breathing and other vital processes. Other nerve fibers in large numbers leading from the brain pass into the spinal cord.

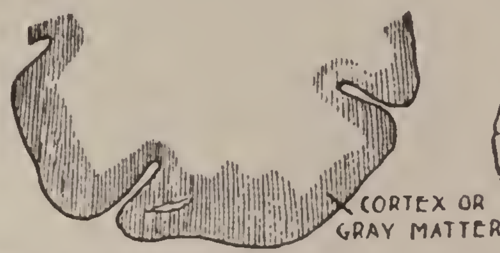


Fig. 211. Section of a portion of the brain; gray matter near the surface.

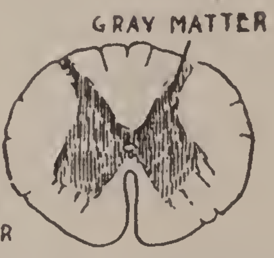


Fig. 212. Section of spinal cord; gray matter on the inside.

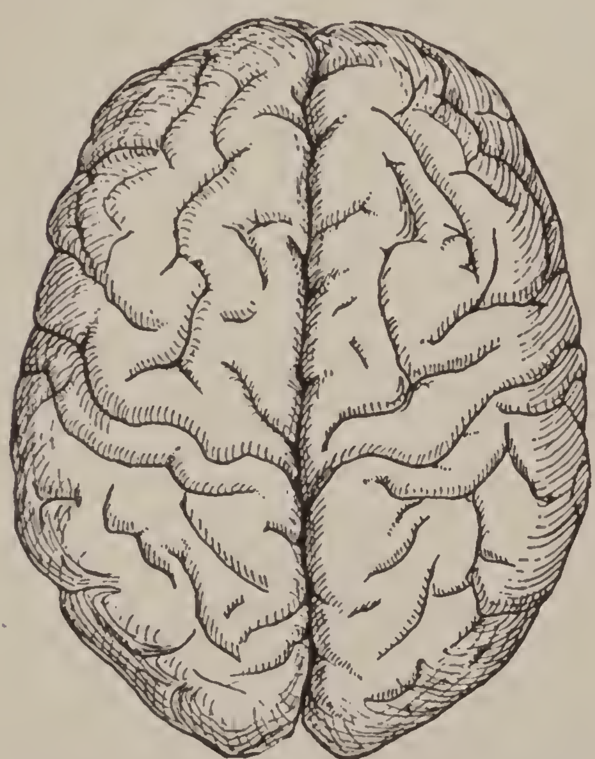


Fig. 213. The brain from above; only the cerebrum is seen.

Ganglia.—The nerve cells are all contained in certain definite parts of the brain and spinal cord, and in certain small collections of nerve cells called, **ganglia,*** that also have a definite location not far from the central nervous system. One region of the brain and of the spinal cord is, then, composed mainly of nerve cells, and this is called **gray matter** (from its appearance in section). The region of fibers is called **white matter.** In the brain the gray matter is on the outer surface, and

*A ganglion is simply a collection of nerve cells. The brain and spinal cord may be considered enormous ganglia.

forms the **cortex** of the brain (Fig. 211); in the spinal cord the gray matter is on the inside. (Fig. 212.)

The brain consists of three main parts: the **cerebrum, the cerebellum and the medulla.***

The cerebrum consists of two halves, the cerebral hemispheres (Fig. 213), connected by a mass of fibers. In a man it is the largest organ of the nervous system, though this is not the case in some of the lower animals, for the higher the animal the larger the cerebrum. The larger the organ is, the more nerve cells it may contain, since the larger size increases the extent of the cortex or gray matter. In man and in several of the more intelligent animals, like the dog and horse, the cortex is further increased by folds or convolutions. (Figs. 213 and 215.) A great number of fibers connect the different parts of each hemisphere of the cerebrum (Fig. 214), connect the hemispheres with each other, and run out from the cells to the spinal cord and to various parts of the body. Those fibers passing from the cerebrum into the spinal cord **cross** in the medulla; so that if the left side of the brain were injured, the right side of the body (except the head) would be paralyzed.

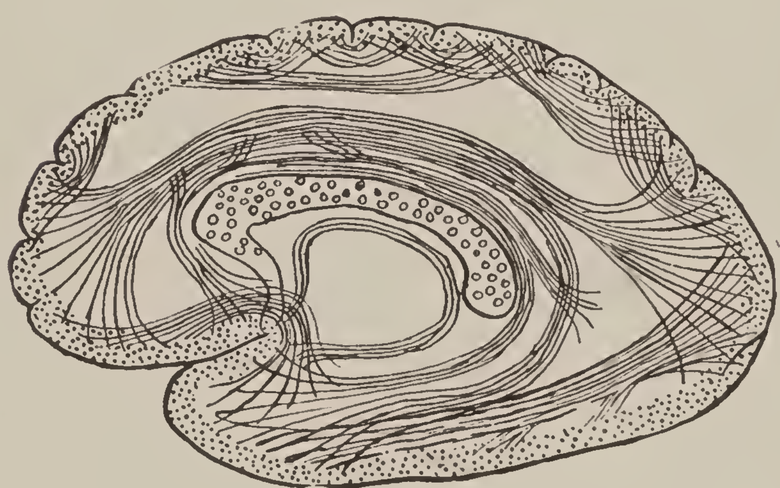


Fig. 214. Nerve fibers connect the parts of the cerebral cortex with one another.

The cerebrum is the organ of the mind. Without it we could

*The medulla oblongata is also called the "bulb."

not know, think, imagine, remember or do anything which we commonly associate with the activities of the mind. In certain parts of the cerebrum, certain nerves that start in sense organs (ear, eye, nose, tongue and skin) have their endings; therefore, without the cells of the cerebrum, we would have no **sensations** of hearing, sight, smell, taste or touch, nor would we feel hungry, tired, cold or warm. In the cerebrum are other cells, also grouped in certain parts of the cortex, from which fibers run to the voluntary muscles; without these cells we could not cause our muscles to obey our will.

The cerebellum lies behind the medulla and below the dorsal part of the cerebrum. The cerebrum is so large in man that it covers the cerebellum, which cannot be seen from above. (Fig. 213.) A frog whose cerebellum has been removed, cannot sit up; or, if thrown into the water, makes an effort to swim, but with irregular and ill-controlled movement. A man whose cerebellum has been injured staggers in his walk as though intoxicated. One function of the cerebellum, therefore, is to keep the muscles ready for action, and to make the muscles used in walking, standing and running act together in an orderly manner, or, in other words, to co-ordinate their action. It probably has other functions not yet understood.

The Medulla.—With both the cerebrum and the cerebellum removed, an animal still lives. If this animal is a pigeon, for example, placing grains of corn on the ground beside it would awaken no response; for without the cerebrum the animal cannot see nor can it will to act; and without the cerebellum it cannot even maintain an upright posture. However, if you place a grain of corn in the pigeon's mouth, the muscles that are used in swallowing will act and the grain of corn passes down the throat. The nerve fibers that carry the impulse of

the grain as it touches the mouth pass to the cells of the medulla, whence fibers pass back to muscles engaged in swallowing. Such action is called **reflex action**, and will be more thoroughly explained below.

If, now, the animal has lost the entire brain, including the medulla, the heart stops beating, the breathing movements cease and death occurs. This proves that these vital movements are under the control of the medulla, which is, therefore, sometimes called the "vital knot." Of course, the fibers connecting the higher parts of the brain with the spinal cord and the various parts of the body pass through the medulla.

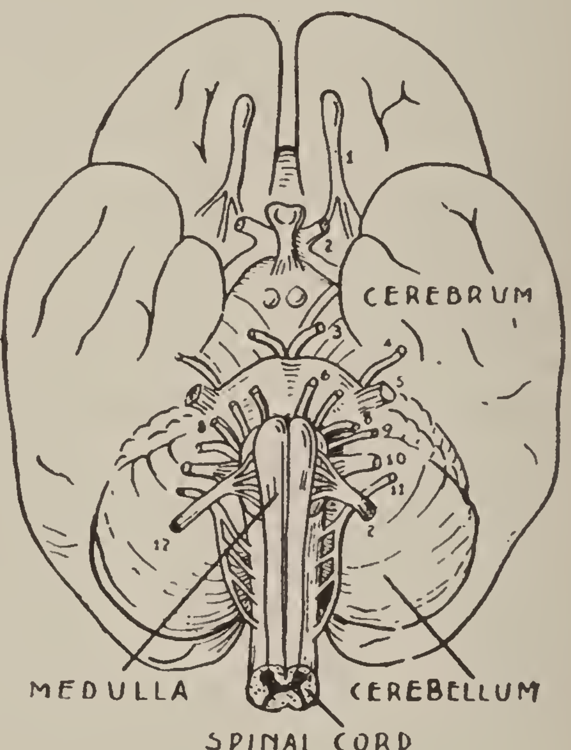


Fig. 215. The brain from below; 1-12 cranial nerves.

Summary.

The brain contains millions of nerve cells in the cortex, or gray matter, and has many fibers running in and out. Many of these fibers are contained in the twelve pairs of cranial nerves that supply the head and some of the vital organs. The brain consists of the cerebrum, the cerebellum and the medulla. The cerebrum performs the higher functions of the mind, as the will, reason, memory, etc. The cerebrum of man is larger than that of any of the lower animals. The cerebellum serves chiefly to co-ordinate the movements of the muscles. The medulla con-

trols the breathing movements, the heart-beat and other vital processes. It is the center of reflex action for parts of the body and also contains nerve fibers leading from the brain into the spinal cord.

Questions.

1. How many pairs of nerves run out from the central nervous system? 2. What are these together called? 3. Where do the branches of the cranial nerves run? 4. What do the flaps at M., Fig. 217 represent? 5. What are the functions of the cerebrum? 6. How would a person with an injured cerebellum act? 7. What is the work of the medulla? 8. Why is the tenth cranial nerve, Fig. 210, the most important one coming off of the medulla? 9. What fibers pass through the medulla? 10. What pictures in this chapter show parts of the cranial nerves?

CHAPTER XXXIX.

The Spinal Cord and Sympathetic System.

From a study of the functions of the divisions of the brain, as described in the preceding chapter, one might conclude that they control all of the actions of the organs. They have, indeed, a variety of duties. But we shall see in this chapter that the spinal cord has independent duties, and that the sympathetic system plays an important part in bringing about harmony of action among the organs.

THE SPINAL CORD.

Description of the Spinal Cord.—The brain ends and the spinal cord begins at the place where the cranial cavity (Fig. 80a) communicates with the spinal canal. An inspection of Fig. 216 discloses the fact that the spinal cord seems to be a continuation downward of the medulla. The spinal cord differs from the medulla in having the white matter on the outside and the gray matter on the inside. (Fig. 212.) The cord is about eighteen inches in length and gives off thirty-one pairs of nerves. Like the brain, it is covered by the meninges (M, Fig. 217), and is further protected by a bony covering, the vertebrae. The relation of the spinal cord and its nerves can best be seen by a study of Fig. 216, and the internal structure by a study of Fig. 217. The gray matter is seen to be shaped in section like the letter H, the four points of the letter representing the four ridges (R) that run up and down

the spinal cord. There are, therefore, on each side two ridges, a dorsal and a ventral, and from each comes off a bundle of nerve fibers called a **root**. So on each side there is a **dorsal root** (DR) and a **ventral root** (VR), which unite outside the spinal cord into a nerve, the **spinal nerve** (N). The dorsal root has a ganglion—the **dorsal ganglion** (DG). The function of these parts has been determined by experiment as outlined below.

Functions of the Spinal Cord.—It was noted above that the spinal cord carried some of the fibers down from the medulla. It thus acts as the pathway from distant parts of the body to the brain and back from the brain to the parts of the body. That it has other functions can be shown by experiment in the same way as the functions of the parts of the brain have been discovered by experiment.

If we take a frog that has been freshly killed by the removal of the whole brain, we find that the spinal cord can act like the medulla in completing certain nerve circuits. If we irritate the chest of the brainless frog, the front legs move to scratch at the irritated parts; or if the skin of the toe is irritated, the foot is jerked away. This shows that nerve impulses pass **into** the spinal cord from the outside (from the chest or the foot, for example), and that impulses pass **out**

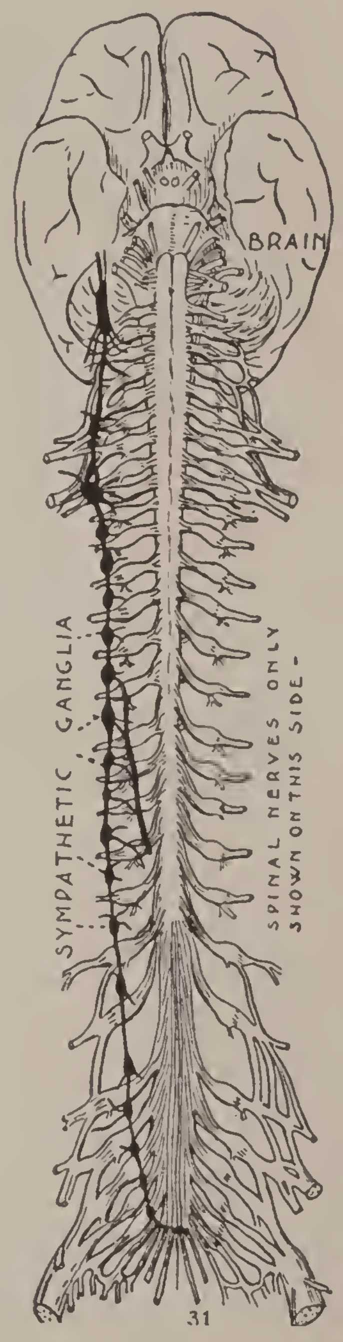


Fig. 216. The brain; the spinal cord with beginnings of its nerves; the sympathetic nerve ganglia of the right side.

again to the muscles to remove the irritated part. When the spinal cord is also removed, no muscular response to irritation occurs. This proves that the spinal cord has the important function of sending the proper message back down the outgoing nerve whenever an incoming message is received. In other words, the spinal cord is the center of reflex action.

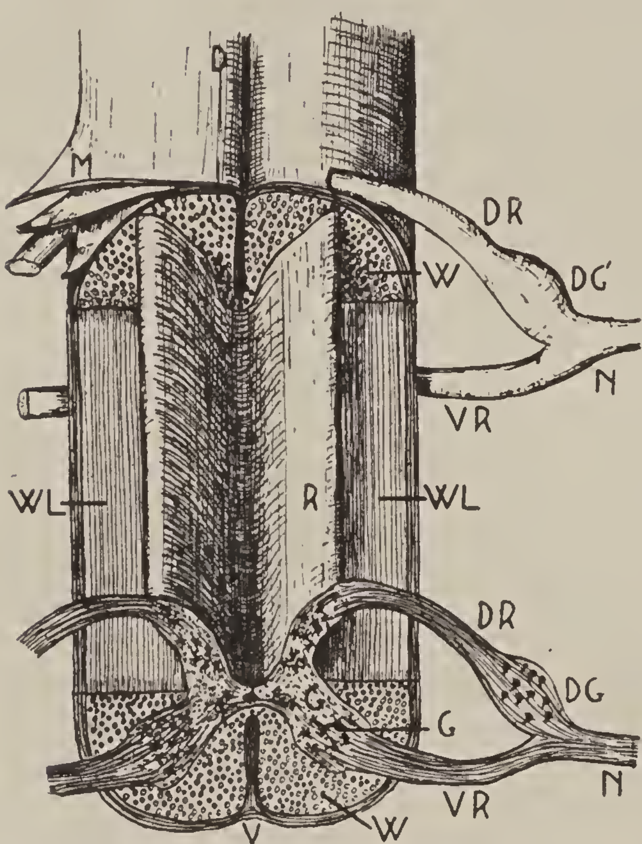


Fig. 217. Spinal cord; cut end with portion of white matter (W) cut away, exposing the dorsal ridges (R). D, dorsal; V, ventral; WL, nerve fibers of white matter cut lengthwise; G, cross-section of gray matter; M, meninges or covering membranes; N, spinal nerve; DR, VR, dorsal and ventral roots; DG, dorsal or sensory ganglion.

Two Kinds of Nerve Fibers.—When you **will** to move your index finger, you send an impulse to the muscles that move it, and the finger moves. When you touch an object with the finger, you feel the object; this time a different impulse passes along the nerve. One kind of impulse goes **out from the center** to a muscle and results in motion. It is called a **motor impulse,** and uses its own nerve cells and their fibers, which are called, therefore, **motor cells** and **motor fibers.** The other kind of impulse comes in from the **outside** to the center, and causes us to feel (if carried as far as the brain), and is called a **sensory impulse.** It commences in a sensory cell, runs along **sensory fibers** and ends in relay cells located in the spinal cord, which send it on to the brain. Most nerves carry motor and sensory fibers bundled up together. In reflex action a sensory impulse en-

ters the spinal cord and is returned by cells of the cord as a motor impulse running along motor fibers to the proper muscles.

Reflex Action.—The path of nerve impulses in reflex action can be demonstrated by the experiment illustrated in Fig. 218. (Compare with Fig. 217.) Suppose the spinal nerve (N) supplies the arm and fingers. Experiments in cutting the

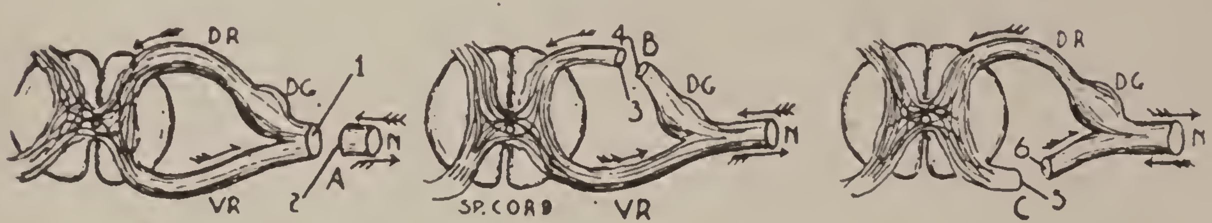


Fig. 218.—Illustrating method of experiment on motor and sensory fibers. A, spinal nerve cut through; B, dorsal or sensory root cut through; C, ventral or motor root cut through. Other letters as in Fig 217. Numbers indicate points where nerve fibers are stimulated in experiment.

nerve and its roots **(VR** and **DR)** would result as follows:

If the nerve **N** be cut at **A**

Irritation at **1** would cause pain.

Irritation at **2** would make the finger move.

If the dorsal root **(DR)** be cut at **B**

Irritation at **3** would cause pain.

Irritation at **4** would have no effect.

If the ventral root **(VR)** be cut at **C**

Irritation at **5** would have no effect.

Irritation at **6** would make the finger move.

What do you learn from this? Sensory nerve fibers pass into the spinal cord by the dorsal root (note the arrow) and motor nerve fibers pass out by the ventral root. The spinal nerve **(N)** contains what kinds of fibers? Any impulse from the fingers or hand (say, touching a sharp point), then, passes up the spinal nerve (N, Figs, 217-219) through the dorsal root

and the cells in the dorsal ganglion to sensory nerves in the dorsal ridge of the spinal cord; here the impulse is passed on to cells in the ventral ridge of the gray matter, which starts a motor impulse that passes out at the ventral or motor root along the spinal nerve to the muscles of the arm. (See Fig. 219.) This is the **machinery of reflex action.** This works so perfectly that the impulses are always sent back to those muscles best calculated to afford relief. The spinal cord is the **reflex center** for a large part of the body—the central station to which sensory impulses come, and where these are passed on to motor cells, causing motion **in the proper muscles.**

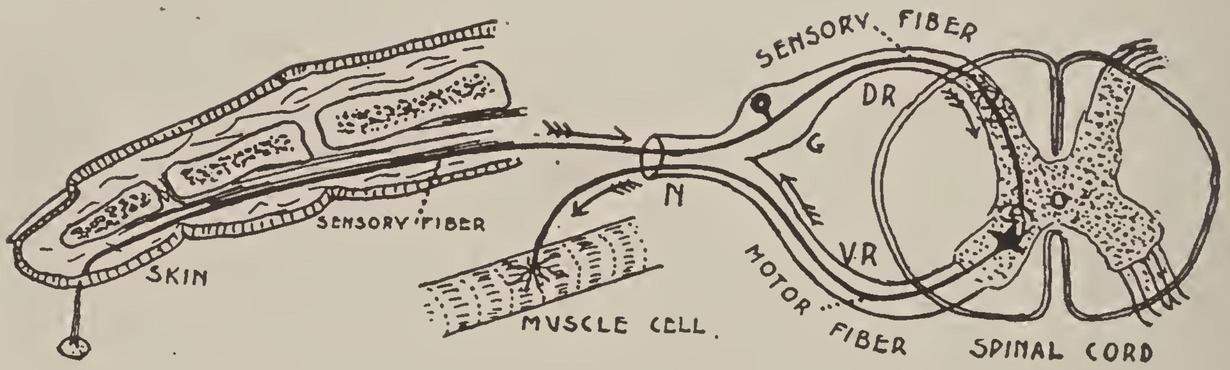


Fig. 219. Diagram illustrating path of nerve impulses in reflex action.

You have noticed that when you touch the point of a tack unawares, your finger is withdrawn before you think. The sensory impulse in the spinal cord is also passed on to fibers leading to the cerebrum, causing there conscious sensation—that is, we feel. After thinking it over, we would will to remove the finger. But this far-around way takes so long that much harm would be done the finger by the tack before we could think it over. The circuit through the spinal cord, the path of reflex action, is rapid and its purpose is largely to protect the body against sudden dangers.

Observation Work.—Give six other examples of how reflex action is of service to you.

THE SYMPATHETIC SYSTEM.

We have thus far studied only the central nervous system and the cranial and the spinal nerves. Closely connected with these by fibers is the sympathetic nervous system, or ganglionic system, as it is also called, because its cells are grouped in numerous **ganglia.** The ganglia are located in two chains, one on each side of the spinal cord close to the backbone (the left one shown in Fig. 220, the right one Fig. 216); and there are in addition to the chains several ganglia and bunches of nerve fibers, called **plexuses,** about the organs of the chest and abdomen, especially behind the heart and the stomach. A blow over the stomach, where the "solar plexus" is located, paralyzes the ganglia there, and may cause sudden death.

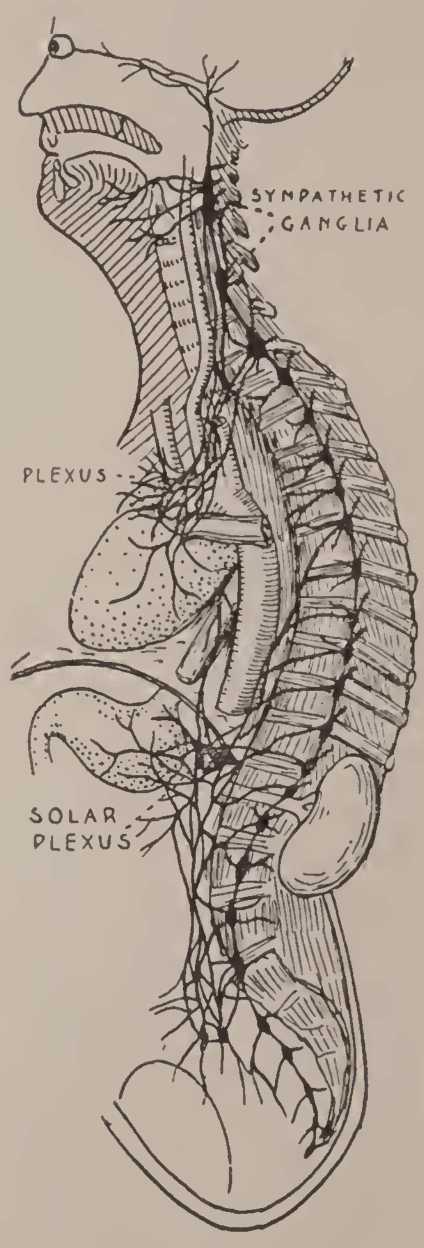


Fig. 220. The sympathetic ganglia and nerves of the left side of the body.

Function of Sympathetic Nerves.—Can you make your heart beat faster or slower at will, as you move your finger at will? When you walk or run it beats faster whether you will or not. After you exercise considerably your skin becomes red and the sweat glands act. All these functions are regulated

largely through the sympathetic nervous system. When you chew food, digestive glands secrete their juices. The organs of secretion, the heart, the kidneys, the muscles of the arteries and the digestive organs are controlled in part by the sympathetic nervous system, and in part by the nerves coming from the medulla. These involuntary acts are called **automatic.** That the cerebrum also has something to do with automatic acts (secretion of saliva, for example,) can easily be seen from the fact that if you watch a person sucking a lemon and making a wry face, or even if you think of this sight (a cerebral act), your mouth will "water." An impulse thus passes along the nerve of sight to the sensory cells of the cerebrum; thence by fibers (Fig. 214) to other brain cells whose fibers run out to the salivary glands. Sympathetic nerves also go to the salivary glands.

Advantages of Automatic and Reflex Action.—In the first place, since the cerebrum is the organ of thought, will, memory and other powers, it is important that we relieve the cerebrum from many of the petty acts of life, so as to leave it free to perform more of the higher functions. Thus, the sympathetic system and the medulla keep us breathing and regulate the heart-beat, make the digestive glands secrete at the proper time—in short, the lower centers attend to all of the automatic acts necessary for life. We could not regulate all of these things if we would. In the beasts of the field automatic action is as perfect as in man.

The reflex centers also relieve the cerebrum. Reflex acts are not only protective, being more rapid than voluntary acts (page 278), but they save us from giving voluntary attention to them. Take walking, for example; a child learning to walk must give his whole attention to the act. If you had to do so you could not find time for much else. So it is with

eating, washing, dressing, tying a knot, or performing a thousand other things that we do without thinking. Tying our necktie is at first a conscious act, and requires the work of the cerebrum; but later, after practice, the cerebellum takes charge, and we tie the necktie while thinking of something else.

Experiment.—Write the word "Practice" on a white sheet of paper. You write it easily and without thinking how each letter was made or how the word was spelled. Now copy the characters in Fig. 221 immediately below the word just written, and after doing so, turn the sheet around and hold it up to the light. Why did you write the first more easily than the second? A child who has never written a word would find it harder to write the word "Practice" than you find it to write the characters in Fig. 221, which is a mirror image of the word "Practice."

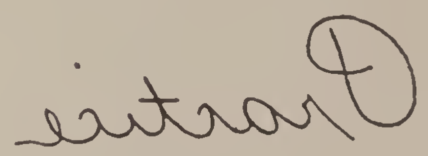


Fig. 221.

It is important in early life to reduce as many conscious acts as possible to reflex acts. When the multiplication table is once learned, that much of life's work is laid aside. One should learn to read, to write, to spell, to draw, to work arithmetic, and to do as many other things as possible early in life so that later these can be performed by the lower centers, leaving the cerebrum free for higher thought. Education should, therefore, begin early, and every day possible should be spent at school.

Habits.—When an act is done once it is easier to repeat it, and the oftener it is repeated the easier it is done and the more one tends to do the act. It soon becomes a habit. Habits are hard to break, for it is difficult for the nerves to act differently from the way they have often acted. Bad habits can be broken, however. The way to "break a habit is to break it." It is difficult, the first time we try; to keep from doing

a bad act that has become habitual; but the second time it is easier, and so on until it becomes a habit to abstain from the act. It is best to acquire good habits and never form bad ones. Habits are mostly formed in youth. This fact makes education in the home and in the school important because education makes a girl or a boy acquire correct habits of thinking and acting. A person with many good habits will be more successful in life than one with bad habits or too few useful ones.

Summary.

The spinal cord has two main functions. First, it carries sensory impulses from the outside to the brain and motor impulses from the brain to the outside. It is, therefore, a cable of fibers and relay stations. The fibers are located in the white matter of the cord and in thirty-one pairs of spinal nerves and their roots; the nerve cells are found in the gray matter of the cord and in the dorsal ganglia of the spinal nerves.

The spinal cord, furthermore, acts as a reflex center; that is, it is able to receive sensory impulses and translate them into motor impulses. This may be called the "short circuit" of reflex action, as distinguished from the "long circuit" through the cord and the brain, which results in conscious action.

The sympathetic nervous system has as its centers certain ganglia in the dorsal wall of the chest and abdomen. It sends out fibers through the body, especially to the vital organs, and helps to connect all the parts and bring about complete harmony of action among the heart, lungs, digestive organs, glands and other organs of the body. The sympathetic nerves are not under the control of the will but act entirely automatically.

Automatic and reflex acts are important, first, to regulate the work of the vital organs, and, second, to relieve the cerebral cells of acts that have become habitual by practice. The right kind of education early in life is, therefore, very important in order that correct habits of work, thought and conduct may be formed.

Questions.

1. Where in the body are the organs pictured in Fig. 216 located? 2. With Fig. 217 before you, describe the structure of the spinal cord. 3. In what direction do impulses pass along motor fibers? 4. Along sensory fibers? 5. Draw Fig. 218 on the board and explain the course of sensory and motor impulses into and out of the spinal cord. 6. Explain exactly how it is that a frog with its head cut off can draw up its leg if its foot is irritated. 7. What is meant by reflex action? 8. Give examples of action of the sympathetic nerves. 9. Why must the vital processes be automatic? 10. State the advantage of reflex action. 11. Why is it best to get as much school education as possible while young? 12. How are habits formed? 13. How may bad ones be broken?

CHAPTER XL.

The Care of the Nervous System.

The nervous system is both the most wonderful and the most delicate part of the human body. It is also more closely connected with our real or spiritual selves than any other part. The nervous system not only co-ordinates all our organs, as has been pointed out in Chapter XXXVIII, but also regulates our relations with the world around us. The care of the nervous system, therefore, becomes the most important problem of hygiene. The man who solves the problem of how to keep an active, efficient nervous system has largely solved the problem of correct living.

This is also a difficult problem, and you cannot expect to learn all about it in a single year. In fact, you must learn a great deal from experience. In this book, we can only hint at some of the important points to bear in mind with reference to the nervous system. These points we may summarize in the following rules: (1) Keep the body in general good health according to the rules of hygiene thus far learned; (2) avoid all stimulants except when they are prescribed by a physician in case of sickness; (3) form good habits; (4) avoid the poisoning which results from germ diseases like typhoid fever, scarlet fever, grip, and others; (5) keep the stomach in good order; (6) avoid worry, overwork and mental strain; (7) sleep sufficiently; (8) take enough recreation.

Habits.—We shall take up first the subject of habits, as stimulants are treated in the next chapter. Habits are men-

tal and moral as well as physical. Among bad habits may be mentioned that of spitting on the floor, which is, of ocurse, a physical habit. A bad mental babit is that of giving poor attention to one's studies. Giving way to fits of anger is a bad habit, both from a moral and a physical standpoint. The sum total of a man's habits forms his character. Most people have more good habits than bad ones, and would have fewer bad habits if they realized how easy it is to prevent a habit if one begins in time.

The nervous system is damaged severely by germ diseases. We often see young people so weakened by a spell of typhoid fever, for instance, that it is years before they can perform with comfort their ordinary duties. All the germ diseases set free poisons in our blood. These poisons injure the delicate nerve cells. While it is not an everyday occurrence to see insanity as a result of the severe infections like smallpox or typhoid fever, such things do occur. If you have ever had the grip, you know how weak, depressed and miserable even a mild germ disease can make you feel. You can imagine, then, the terrible harm that can result to the nervous system when a patient lies for weeks in a delirium due to the poisons of typhoid fever. From a standpoint of prevention, therefore, many nervous diseases are germ diseases. That is, they are caused by germ diseases, and if we prevent the germ diseases, we prevent the nervous diseases which follow.

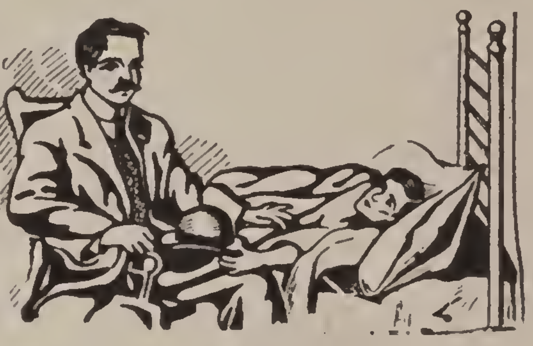


Fig. 222. All the catching diseases leave the nervous system weakened to a greater or less degree.

A deranged stomach also is very important as a cause of nervous disease. The stomach is very richly supplied with

nerves, both from the brain and from the sympathetic system. The solar plexus (Fig. 220) supplies many nerves to the stomach. The close connection between the stomach and the nervous system is shown by the fact that fright can make some people sick at the stomach, or nauseated. Strong excitement or anger interferes with appetite and digestion. For this reason, it is very important that only pleasant topics should be discussed at meal time. Also, if we are careless in our eating habits, and swallow the food hurriedly, or eat at irregular hours, or fail to masticate our food properly, it is very likely to upset the stomach and make us very nervous and miserable. There is one kind of dyspepsia that is called nervous dyspepsia; few people are so completely miserable as these nervous dyspeptics.

Overwork.—A reasonable amount of work helps to keep the body in good condition and makes one enjoy his leisure and his sleep. But this work must be regulated according to the strength of the worker. One man can stand twice as much work as some other man. It is said that Mr. Edison, the inventor, can work eighteen hours a day for days at a time; but it is likely that this would wear out the average man in a week's time. Some people of delicate constitution can work only an hour or two at a time without being fatigued. When one works too long or too hard, he notices that he cannot do quite as good work as usual, and that he does not enjoy his work as much. If he keeps on trying to drive himself to work as hard as ever, he finds that

Fig. 223. This represents a man who has been very much overworked.

he is depressed and becomes discouraged easily. He gets the "blues," and becomes more irritable than is his habit. He is likely to become nervous and sleepless, and may lose weight. He feels tired even on rising in the morning, and spends a very miserable existence indeed.

It is often difficult to say whether a boy is overworked or whether he is merely lazy. One indication of laziness in work is that the individual is interested in something outside of his work, a thing not likely to be the case with an overworked boy.

We should remember, however, that people of an enthusiastic, eager disposition are more likely to overwork themselves than those of a reserved, smooth temperament. If you are of an enthusiastic disposition, there may be times when you feel overworked, and in these times you should talk with some older relative, such as a father, sister or guardian. Oftentimes an outsider can plainly see what we ourselves overlook.

A nervous breakdown resulting from overwork, is a serious matter in the case of people of moderate means. The cure for it is a change of scene and habits, which is expensive. Hence it is wise to avoid a breakdown. Longer hours for sleep and recreation, and more cautious use of exercise should be begun as soon as signs of a nervous breakdown occur.

Sleep.—One who sleeps enough is not likely to suffer a nervous breakdown. Sleep is the cure for worry and overwork. A child of twelve should sleep nine to eleven hours a day. A man doing hard physical labor should sleep at least eight hours a day. Intellectual laborers should sleep an hour more. Those who have a delicate constitution should take a nap in the middle of the day, especially in warm weather.

Recreation is next to sleep in importance. Every man needs some exercise which he can take with so much pleasure that he forgets himself. That is the true test of recreation: if it causes the player to forget himself in the enjoyment, it is true recreation. Men who perform hard physical labor usually like some recreation which employs the mind more than the body, such as music or reading. Intellectual workers usually prefer some form of recreation which calls the muscles into play, like tennis or hunting. Any exercise that is done for the sole purpose of building up the body, especially if it is unpleasant, is not true recreation. To get the most good out of recreation, it must be enjoyable. In Texas, the climate is such that outdoor exercise can be enjoyed all the year around, and all persons who have a nervous tendency should try to spend a large part of the time out of doors, provided they can find some congenial occupation or recreation.

Fig. 224. Sleep is the greatest restorer of wornout nervous systems.

The Nerve Cells.—The nerve cells are the seat of those nervous changes which go to make up our conscious life. When the nerve cells are well nourished and fresh, we feel well; when the nerve cells are tired, exhausted, or starved, we feel bad. The nerve cells are so delicate that we cannot handle them after death without destroying them, and so, up to this time, we have never seen many of the changes which occur in nerve cells as a result of fatigue or of poisoning. This is best seen in the cells of animals which are hard at work all day, such as the bee or the swallow. If the central nerve cells of these

little beings are examined at night, they appear shrunken and irregular in outline. In the morning, while the little creature is fresh and strong, the nerve cells seem to be well rounded out. This is shown in Fig. 225. We know, then, that we cannot do good work with wornout nerve cells or with poisoned nerve cells. Disease germs, alcohol or morphine cause poisoning of the nerve cells. Rest, recreation and sleep restore the cells to their proper strength and vigor.

Fig. 225. The picture to the left is a fresh, unfatigued, nerve-cell. The middle picture is a moderately fatigued nerve-cell. The picture to the right is a nerve-cell poisoned by alcohol or disease.

Just as the mind is the highest function of the nervous system, so the judgment is the highest faculty of the mind. Nowhere in life de we need good minds and good judgment more than in the regulation of our lives so as to keep our nervous systems in good order.

Important Points.

The enemies of a good nervous system are as follows:

1. General poor health from other causes.
2. Stimulants, such as alcohol, tea and coffee.
3. Bad habits, and excesses of all kinds.
4. Germ diseases like typhoid fever.
5. Improper habits of eating, causing imperfect digestion.
6. Worry, overwork and mental strain.
7. Lack of sleep and recreation.

Questions.

1. Name some stimulants which may cause nervous disease. 2. Name all the germ diseases which you know. 3. Name some bad habits. 4. Explain why the stomach is concerned in nervous disorders. 5. Explain the importance of sleep. 6. Explain what is meant by recreation. 7. If a man practices with dumb-bells in order to gain muscle, is this recreation? 8. How, then, can you tell whether an exercise is true recreation or not? 9. What is the difference between the nerve cells of a bee early in the morning and at the close of a busy day? 10. What kind of persons are likely to be overworked?

CHAPTER XLI.

Alcohol, Narcotics and Stimulants.

In the pages that have gone before you have learned how the liquid poison called alcohol can injure the various organs of the body, but this poison acts in such a stealthy and peculiar way that we shall devote some time now to the study of the poison itself, how it affects the human body, and how to avoid it.

Alcohol.—Pure alcohol is a clear, colorless liquid, somewhat lighter than water. It mixes with water very readily, and in so doing produces some heat. Alcohol evaporates rapidly, and for this reason, when placed on the skin, feels cool as it evaporates into the air. If it be placed on the skin and then covered, however, it feels hot and causes reddening of the skin. It is made from fermenting sugars. In the process of making alcohol, the yeast germs change the sugar to alcohol, and in so doing they cause carbonic dioxide to bubble out of the fluid. If the yeast germs are allowed to remain in the water and sugar solution, there comes a time when they have formed so much alcohol that they can no longer live in the mixture, and they die. Other germs are less able to live in the alcohol solution than the yeast germs.

From this it might be supposed that alcohol is good for us, because it kills germs. But in the chapter on disinfectants we have already learned that if we desire to kill germs in the human body we must use something more poisonous for the germs than for our bodies. Alcohol is just as poisonous for

us as it is for the germs, and in fact, it gives the germs the advantage by upsetting our system. So it is not a useful drug for killing germs in the human body.

Percentage of Alcohol in Whiskey, Beer and Wine.—We have learned that pure alcohol is a clear liquid; but the drinks sold to the public do not usually contain more than fifty percent of pure alcohol. Whiskey and brandy contain about

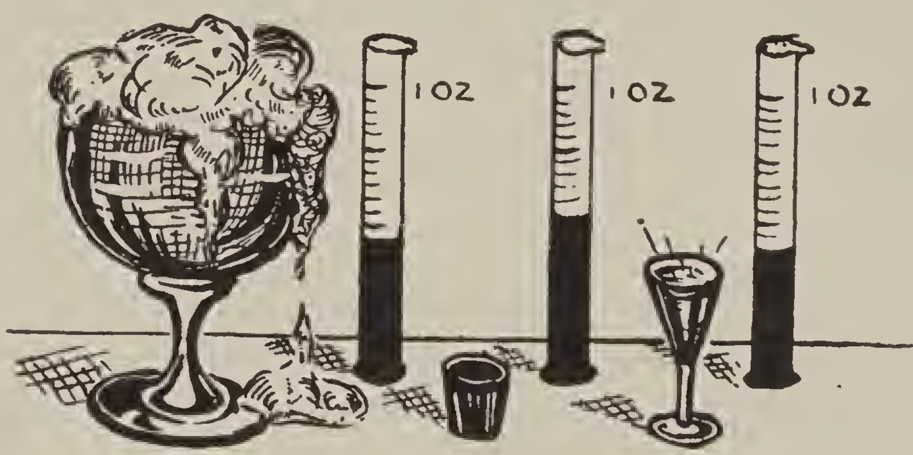


Fig. 226.—Although beer and wine contain a lower percentage of alcohol than whisky, a drink of beer contains about the same amount of actual alcohol as a drink of whisky. The tall graduated glasses represent the amount of absolute alcohol in a single drink of beer, whisky, and wine.

fifty percent alcohol. The wines contain from seven to twenty percent and beer contains from one to five percent of alcohol. Practically all that any of these liquors contains in addition to the alcohol is some sugar, flavoring and coloring matter. The picture shows that the amount of pure alcohol contained in an ordinary drink of whiskey is about the same as that contained in a drink of beer or wine.

It is most remarkable how this alcohol attacks each and every organ of the body with which it comes in contact.

The stomach is affected very badly by alcohol, and it becomes inflamed from the irritating action of liquors containing this substance. Indigestion, loss of weight, and a general

condition of invalidism are signs of the bad effects which the alcohol has on this particular organ. The liver feels the presence of alcohol also, and shows it by becoming tough and fibrous from the scar tissue or connective tissue, which is caused by alcohol. When this has once developed there is no hope for the patient ever to recover, and as a rule the drinker does not know he is threatened with this trouble until it is too late.

The respiratory system is affected somewhat by alcohol. The fumes or odor of alcohol can be detected in the breath, which means that the lungs are doing their part to throw the poison out of the system. The main point, however, is that alcohol makes people so much more susceptible to the inflammations of the lung, such as pneumonia. Persons that drink alcohol are more likely to die when they have pneumonia than others. Physicians always inquire if a patient has used alcohol whenever they are called in to treat a case of pneumonia. This disease is dangerous at any time, but especially so when it occurs in drinkers.

The kidneys help the lungs rid the system of alcohol, and in throwing this poison off the kidneys are somewhat injured. Their injury is one that can never be repaired, and when a drinker has caused nephritis or kidney disease by his bad habits, it is too late to remedy the matter. Nephritis means an injury of the little kidney cells (XYZ, Fig. 174). Like the liver cells, the kidney cells are replaced to some extent by connective tissue when they are inflamed.

The heart is injured by drinking alcoholic liquors because the liquid has to be pumped to the lungs and to the kidneys to be thrown off from the body. The heart is made to pump more blood than the needs of the body demand; and it seems reasonable to suppose that a heart is overloaded when

one drinks much liquor. The alcohol in the blood also hardens the arteries and causes the growth of scar tissue, which can be seen in spots in the arteries after death.

The muscles and bones are injured by alcohol, because they suffer from want of good food. If the stomach is inflamed, it cannot prepare food for the body's needs, and for this reason persons who drink large amounts of alcohol are usually weak and feeble.

The nervous system is so delicate and so wonderful that it must be taken care of properly or it will certainly get out of order. The most wonderful watch that was ever made, when compared with the human nervous system, is as clumsy and awkward as an ox wagon. The delicate machinery of brain, spinal cord and nerves has to do with the proper control of our organs and also with our thoughts. Think what dreadful consequences must follow the injury to these little cells which form our thoughts. Alcohol does injure them, for alcohol is the cause of more cases of insanity than any other cause except heredity. Probably about twenty percent of all insanity is due entirely to alcohol.

How the Drink Habit Is Formed.—It is not stated anywhere in this book that all persons who use alcohol will develop any of the diseases mentioned. In fact, there are some people who do not seem to be injured by alcohol, so far as we can tell. Such persons are to be compared with typhoid carriers. You remember that some persons have the typhoid germs in their bodies without showing any symptoms. These persons are well and strong, and so far as they are concerned are none the worse off for having the germs; but they spread the disease to others. So it is with drinkers: some of them take the alcohol into their systems without showing any immediate ill effects on themselves, but they spread the drink habit. Other

young men and boys see them drink, and follow their example. In the case of germ diseases, a person who has a mild case may give the disease in its worse form to another person; so, a man who drinks just a little can give the germ of the habit to another man, who may drink himself into his grave or into the asylum.

Probably all of you know how low alcohol can drag its victim. You have no doubt heard of or possibly seen a drunkard, with his staggering gait, his unkempt hair, and his bleary eyes. Such a poor drunkard goes about exposing himself to the weather, and leaves his family to look out for themselves. He is not himself, and that marvelously beautiful instrument, the brain, is in such poor working order that he is little better than an idiot. A drunkard may scowl at his best friend, as though he hated him, or may speak roughly to a little child; on the other hand, he may look on a scene of sadness and chuckle as if it were a joke.

You may be sure that no man ever expected to be anything like this when he took his first drink. And yet it is impossible to tell beforehand just who will develop into a drunkard.

Since, then, alcoholic drinks are absolutely worthless to the user, and may cause irreparable harm to body and mind, it is best never to begin to drink. When invited by a friend to drink with him it takes "grit" and force of character to refuse to be led into so dangerous a habit. Make up your mind that, when you are in the situation of the young man shown in Fig. 227, you will decline.

It is wise for business reasons to leave alcohol absolutely alone, for many business firms will not employ anyone who drinks. This is true especially of banks, railways and other business firms who are entrusted with people's property or people's lives. **Athletes,** who are ambitious to ex-

cel, always leave alcohol alone when preparing for a contest. **Locomotive engineers** must not drink, for the lives of the passengers are in their hands. **Lawyers** must work hard at times, and sometimes an innocent man's life depends on the good work of the lawyer defending him; in a case of this kind alcohol is a hindrance. The **physician** fighting disease cannot afford to drink, as it would make him unfit to give advice to the patient depending on him. In fact, it might be said that any good work demands of a man that he leave alcohol alone. Drinking is out of place in the life of any ambitious man. It is a job to itself, and should be left to those who have no ambition or desire to take part in the work of the world.

Fig. 227. The first drink is almost always taken to accommodate a friend. Have your mind made up beforehand never to take the first drink.

Tea and Coffee.—Somewhat akin to the alcohol question, but of less importance, is the tea and coffee problem. Both tea and coffee contains a substance which in its pure form exists as white crystals, called **theine** or **caffeine.** This substance acts as a powerful stimulant to the muscles, the nerves and the mind. After the first effect passes off, the drug causes a certain amount of depression and discomfort. In mild doses it is not very harmful to some people, but it is always risky to tamper with stimulants. In the long run, any man can do more work without stimulants than with them.

It is rather cowardly to take stimulants in order to stand up under a special strain. A man should face his trials manfully, whether they are an extra hard day's work, a tedious examination, or some other hardship. It undermines a man's self-reliance to use stimulants to give him temporary strength to perform his duty.

Opiates.—Caffeine is one of the strongest stimulants we have, and it does increase capacity for work temporarily. It stimulates the intellectual faculties or thinking powers of the brain. There is another drug which stimulates another part of the brain, and this drug is opium or morphine. Opium is the dried juice of the poppy, and morphine is a white crystalline substance which represents the strength of opium. Opium and morphine do not increase the intellectual powers, but they stimulate the imagination and relieve pain. These drugs are even more deadly than alcohol, because they are likely to cause the opium or morphine habit. You can have no idea how these drugs cause one to long for them after having taken them a few times. When the effect wears off and the dreadful after-effect comes on, the poor morphine **habitue** is nervous and miserable, and frequently ends his life. It is very hard to shake off the morphine habit. It is against the law for these things to be sold in Texas except on a physician's prescription, and all conscientious physicians take precautions in the use of these deadly drugs, in order to prevent their patients from forming the habit. Laudanum, paregoric, Dover's powder, cocaine, some headache powders or capsules, belong to the same class of remedies. It would be well for you to make it a rule never to take any medicine to relieve pain except on the advice of a competent physician or dentist.

Important Points.

1. There was never a drunkard yet who believed at the time he took his first drink that he would become a drunkard.

2. Alcohol injures all the organs of the human body, but does its greatest harm to character.

3. The first drink is usually taken to accommodate a friend.

4. Tea and coffee act as stimulants, but in the long run do not increase one's ability to perform work.

5. Morphine, opium, soothing syrups, headache powders and capsules, should only be taken under the advice of a competent physician.

Questions.

1. How is alcohol made? 2. Alcohol does not help the body destroy germs, although alcohol itself will kill germs. Why is this? 3. In what way does alcohol do its greatest harm to the body? 4. Since beer contains a smaller percentage of alcohol than whiskey, explain why it is that a drink of beer contains as much alcohol as a drink of whiskey. 5. Why is it dangerous to take medicines to relieve pain without consulting a physician?

CHAPTER XLII.

The Special Senses.

General Sensations.—It was noted above that there are two kinds of nerve fibers, sensory fibers carrying impulses into the central nervous system, and motor fibers, carrying impulses out to the muscles. In reflex action sensory impulses may pass only to the spinal cord and be there changed to motor impulses that pass out to the muscles. If the sensory impulses reach the cerebrum they result in sensations. When meal-time arrives we feel hungry; if water is needed, we are thirsty. **Hunger** and **thirst** are due to impulses that arise from all parts of the body. They are, therefore, called **general sensations.** A feeling of **fatigue** and of **nausea** are other general sensations. They are useful in serving as a guide to the general condition of the body.

The Special Senses.—The special senses **(touch, taste, smell, sight, hearing,)** differ from the general sensations in that each has a special organ that has to do with a particular kind of sensation. Thus the skin is the organ of touch, the tongue of taste, the nose of smell, the eyes of sight and the ears of hearing. These organs are called the **organs of the special senses,** by which we feel, taste, smell, see and hear. The special senses are the five gateways of the mind, for through them we learn all we know about the things around us. Since this is true, it is very important that we train the senses so that they may, through practice and habit, become our skillful servants.

Four Conditions Needed for Sensations.—In studying the

special senses we must remember that, to have any sensation, a number of things are necessary. (1) There must be a proper **stimulus,** for without something touching the skin we could not feel, or without light we could not see. (2) There must be cells (the **"end cells")** in the sense organ to catch up these stimuli, magnify them and translate them into nerve language and pass them on. (3) From the end cells **sensory nerve fibers** must take the nerve impulse to the brain; if the nerve of sight were cut, for instance, we should be blind. (4) The **cortex of the cerebrum** must be active, so as to receive the impulse and produce the sensation. If any one of these four is absent or injured, there can be no sensation. In studying the sense organs we shall make it a point to study the location of the end cells and to discover how the various stimuli reach these cells.

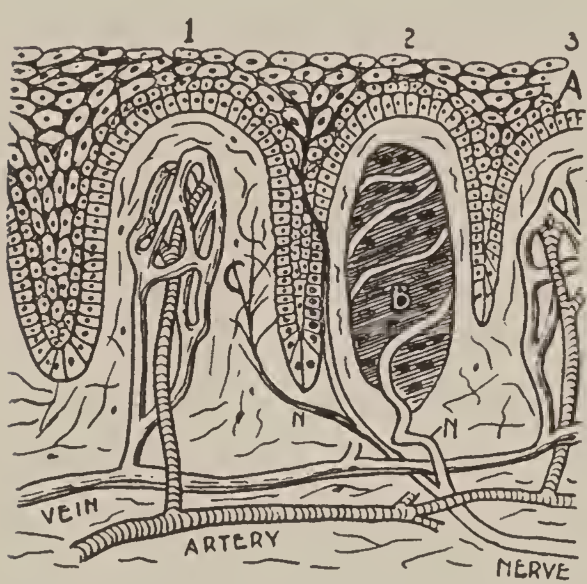


Fig. 228. Papillae of the skin; A, epidermis; 1 and 3, papillae with blood vessels; 2, papilla with **touch bud.**

Touch.—The skin is the organ of touch. As shown in Fig. 176, and again in B, Fig. 228, there are, in the dermis nearest the epidermis, groups of cells called "touch buds," among the cells of which the sensory nerve fibers end. When an object touches the skin, it presses against the touch buds and stimulates the nerve fibers; the impulses are then carried to the brain and we have the sensation of touch. If the pressure is even over the skin we feel the object as smooth; if the pressure is greater in spots, we feel the object as rough. Hard, soft, sharp, dull, etc., describe how objects feel from the way they press against the skin.

Experiments on the Sense of Touch.—(1) Some parts of the skin are more sensitive to pressure than others, as can be observed readily by experiment. Take a bristle from a whisk-broom or clothes-brush and press it against the skin of the nose, forehead, lips, back of neck, tips of fingers, etc. (2) Another test for sensitiveness of touch can be made by finding out for any region of the skin the greatest distance apart two points pressing on the skin will be felt as one point. Take a blunt pair of scissors and place the two points, separated one-sixteenth of an inch, on the tips of the fingers of a person, who should have his eye shut or be looking away. Are they felt as one point or two? Repeat the experiment for different regions of the skin, separating the points more or less. At the tip of the tongue two points can be distinguished as two when only one-sixteenth of an inch apart, or less; on the back of the neck the points may be several inches apart and still felt as one point. Try this on different persons, but try to confuse the person experimented upon by alternating the application of a single point and of two points.

The Temperature Sense.—At some places in the skin certain nerve fibers end in cells not a part of touch buds. These are fibers that carry sense impulses of heat and cold.

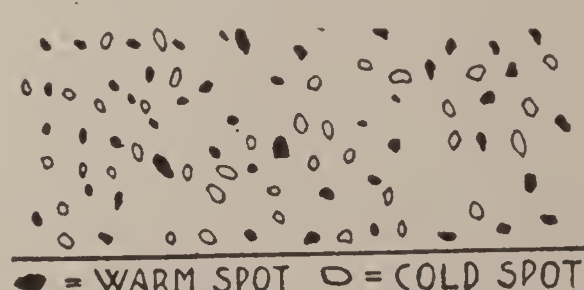


Fig. 229.—"warm" and "cold" spots from a portion of the skin of the wrist; natural size.

Experiments.—Mark out a spot one by two inches on the inner surface of the forearm. With a small blunt-pointed piece of metal (as a nail) colder than the body, find the cold spots by moving the metal slowly over the surface. Mark the cold spots with red ink. With a warm piece of metal find the warm spots in the same way, marking with black ink. (See Fig. 229.) Try it again the next day. Do the nerves at these spots act the same each day? Do you think there are special nerve fibers that carry special messages to the brain?

As there are likewise spots in the skin that cause **pain** when stimulated, these also may be located. Pain is in part a general sense,

and nerves carrying impulses to the brain cause pain when strongly stimulated. Pain is useful in that it gives warning of danger and teaches us what is harmful to the body, so that conditions causing pain my be avoided.

Taste.—If we say the skin is the organ of touch, then the tongue is the organ of taste. Just as there are touch buds in the skin, so there are taste buds in the tongue. They are located on the sides of the elevations or papillae of the tongue. The largest of these are located in two rows near the back of the tongue and other smaller ones are scattered over the tongue. (Fig 230.) A cross-section of one of the large papillae is shown in Fig. 231. The taste buds are located in the epithelial layers in the sides of the papillae, and are seen to consist of long spindle-shaped cells (1 and 2, Fig. 232) with their points coming together at the taste pores (P). Among some of these cells (2) arise fibers of the nerves of taste (N), branches from certain cranial nerves. Substances are tasted by being taken up by the taste cells of the taste buds, which in turn stimulate the nerves of taste. Only liquid substances can be tasted because only these can be absorbed by the taste cells. The sense of taste is useful in helping to guide animals in the selection of their food and to stimulate the digestive juices. How does saliva help us to taste starchy food? (See experiments, page 154.)

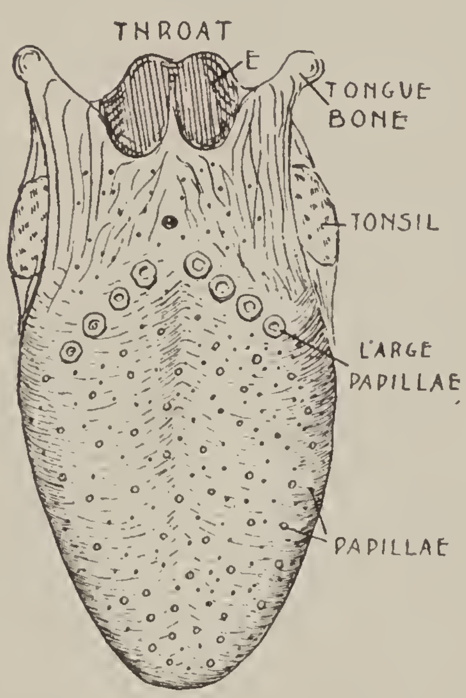


Fig. 230. The Tongue.

Smell.—Only sweet, sour, bitter and salty substances can be

tasted. We distinguish among flavors largely by the sense of smell. Closing your eyes and holding your nose, let some one

FIG. 231

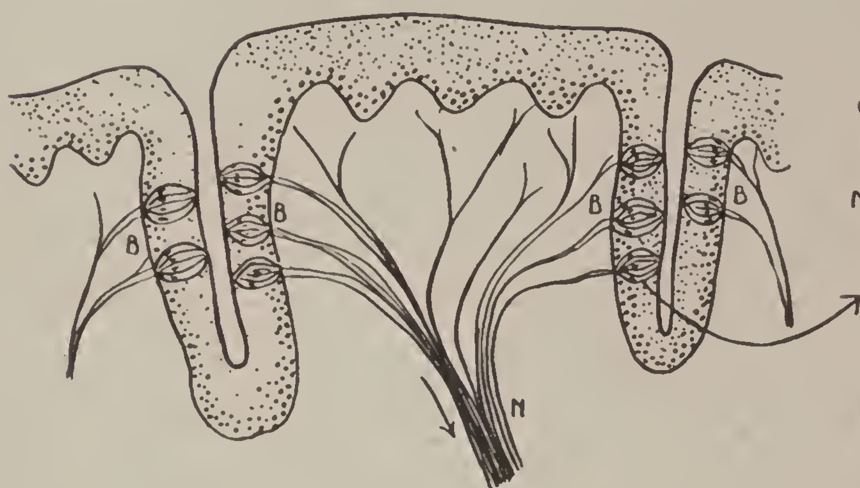


FIG. 232

Fig. 231. Section of a large papilla of the tongue, showing taste buds (B) and nerve of taste (N).

Fig. 232. A taste bud of 231 more enlarged; P., taste pore; 2, "taste" cell; 1, supporting cell.

lay on your tongue successively a slice of apple, of potato and of onion. Can you distinguish them by taste alone? In order that the nerves of smell may be excited, gases or tiny particles floating in the air must enter the nasal passages. Study Fig. 133 and note two ways by which odors may pass into the nasal passages. The nerves of smell make up the pair of first cranial or **olfactory nerves.** (Figs. 233 and 210.) The branches of this nerve are spread out over the ir-

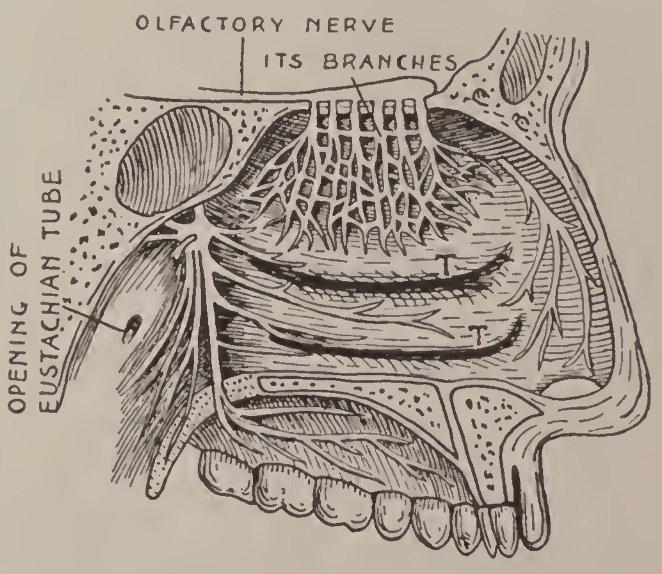


Fig. 233. The nerve of smell at the base of the brain and the branches in the upper part of the left nasal passage.

regular inner surface of the nose (Fig. 233) and pass through holes in the base of the skull to make up the olfactory nerves.

The end cells of smell are located in the mucous membrane of the nasal cavities. Here are two kinds of cells; long epithelial cells (Fig. 234) and spindle-shaped cells with a long projection at one end and nerve fibers at the other. The cells with the nerve fibers are the "smelling cells." Particles of matter are sniffed in with the air and, striking the ends of the smelling cells, stimulate them. The impulses are passed on to fibers of the olfactory nerves, and thence to the brain. Have you any idea how tiny a particle may stimulate the smelling cells? Can you explain how a dog can find his master through a crowded street, even after the master has passed some time before, and out of sight of the dog? Smell is a useful sense in enabling us to detect harmful gases in the air, such as fuel gas and odors that indicate disease breeding objects in the surroundings. Foul odors are disagreeable because Nature intends that human beings must be cleanly and healthy. How is the nose a good detector of impure air in a schoolroom?

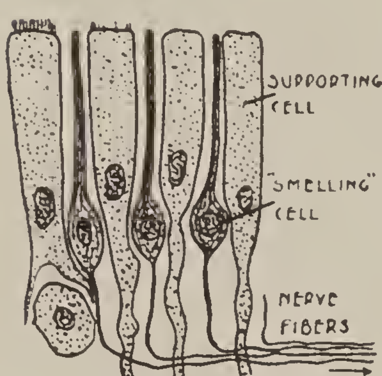


Fig. 234. "Smelling" cells from the mucous membrane of the nasal passage.

Summary.

The special senses are those of touch, taste, smell, hearing, and sight. Certain organs can be designated as the organs of the special senses: the skin, the tongue, the nose, the ears and the eyes. In these organs are special cells, the "end cells," whose duty it is to take up the stimuli, such as objects strik-

ing the skin (touch), substances in solution (taste) or in the air (smell). The end cells magnify these stimuli and pass them on to the nerve fibers leading to the cerebrum. Here the stimuli are translated into sensation, and we feel, taste, smell, etc. The end cells of touch are in touch buds in the skin; but temperature nerves end in scattered cells. The end cells of taste are in taste buds of the papillae of the tongue and the end cells of smell are in the upper part of the nasal passages scattered among the cells of the mucous membrane. In every case the nerve impulse must be carried to the cerebrum to result in sensation.

Questions.

1. Mention some general sensations. 2. What is the use of these? 3. Why can you not designate organs of general sensations? 4. Name the special senses and give the organ of each. 5. What is the function of the end cells in the sense organs? 6. What other conditions besides end cells must there be before we can experience sensations? 7. Illustrate this in the case of sight. 8. Where are the end cells of touch located? 9. What parts of the skin have you found to be most sensitive to touch? What is meant by temperature sense? 11. How can you show that there are special nerves to carry impulses of heat and cold? 12. What is the function of the papillae of the tongue? 13. Where are the end cells of taste located? 14. Of smell? 15. Why are taste and smell easily confused? 16. What are the uses of (a) the sense of touch? (b) Of smell? (c) Of taste?

CHAPTER XLIII.

Hearing.

Taste is a more delicate sense than touch, and smell is more delicate than taste. Hearing is still more delicate. What is it we hear? Sound, you say. When two objects are struck together, as when a bell is rung, invisible **waves of air** are produced, called **sound waves,** which radiate out from the center in all directions as do waves of water on the surface of a quiet pool when a rock is thrown into it. The sound waves are caught up and transmitted to certain cells in the ear where the nerve of hearing (**auditory nerve**) ends. Since the hearing organ is so delicate, it is encased for protection in the bones of the skull.

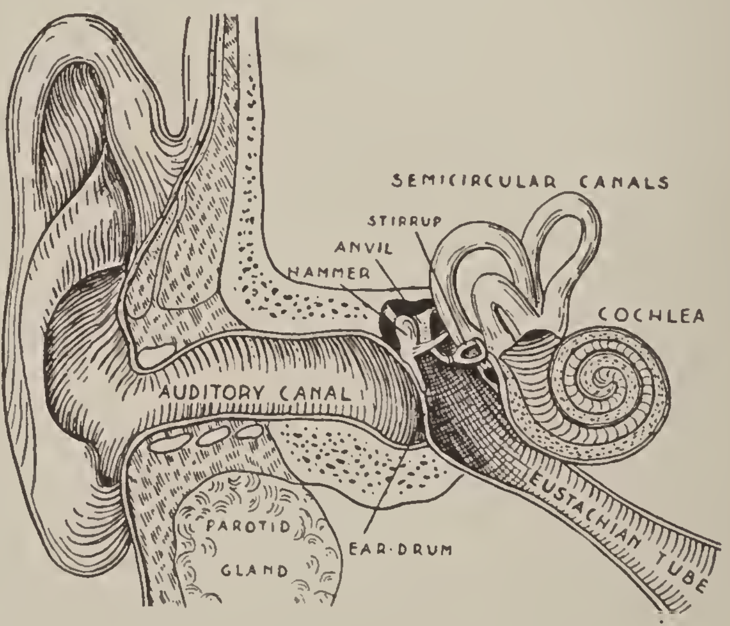


Fig. 235. Diagram of a section of the ear, showing outer, middle and inner ear.

The Outer Ear.—The ear consists of three parts or regions: the outer, the middle and the inner ear. The outer ear consists of the shell-shaped outer part that serves to collect the sound waves; and a canal, the **auditory canal** (Fig. 235) that conducts the sound waves to a membrane, the **tympanum** or

ear-drum, at its bottom. The tympanum may be likened to a drum-head: when the drum-head is beaten it vibrates; so, too, the tympanum vibrates when sound waves strike it. Hearing would be imperfect without the tympanum. To protect it from injury, the auditory canal is crooked, and has glands in it that secrete yellow bitter wax which keeps insects away from the tympanum. Under no circumstances should anyone try to remove objects from the depths of the canal with any hard instrument for fear of injury to the tympanum.

The middle ear is likewise hollow, and communicates below through the **Eustachian tube (Figs.** 233 and 235) with the pharynx and through this with the outside world. Thus air can get to the tympanum from both sides. Do you see why this is? Your physical geography teaches that atmospheric pressure varies with the weather. If the pressure were greater or less on the outer than on the inner surface of the tympanum, this organ would be stretched, causing pain. Indeed, during a cold, the Eustachian tube may become stopped up and earache result. Sometimes an ear-drum is broken by a loud sound like the report of a cannon. If the Eustachian tube were in good condition such an accident would probably be prevented by simply opening the mouth when the cannon is discharged.

How, then, do the sound waves cross the middle ear? Attached to the tympanum is a bridge of three bones, named from their shape, **hammer, anvil** and **stirrup**. (Fig. 235.) These bones are even more important for hearing than the tympanum. The hammer is attached to the tympanum, the anvil is in the middle and the stirrup is next to the inner wall of the middle ear. These bones vibrate with the vibration of the tympanum, and as they do so the stirrup "knocks" at the door of the inner ear, causing corresponding vibrations in this organ.

The inner ear is made up of two parts: the **cochlea** and the **semi-circular canals.** Of these only the cochlea functions in hearing, **for therein are the nerve endings that take up sound waves.**

Cochlea means snail-shell. (Fig. 236.) As in a snail-shell, the hollow winds round and round to the top, so in the cochlea, a canal winds round two and one-half times to the top and then turns back. There are really two canals, communicating at the top and separated all the way by a partition. Now, on this partition there are cells with tiny hairs: these are the **end cells of the auditory nerve,** the cells that catch up sound waves and transmit the impulse to the auditory nerve, which carries it to the cerebrum as sensation of sound.

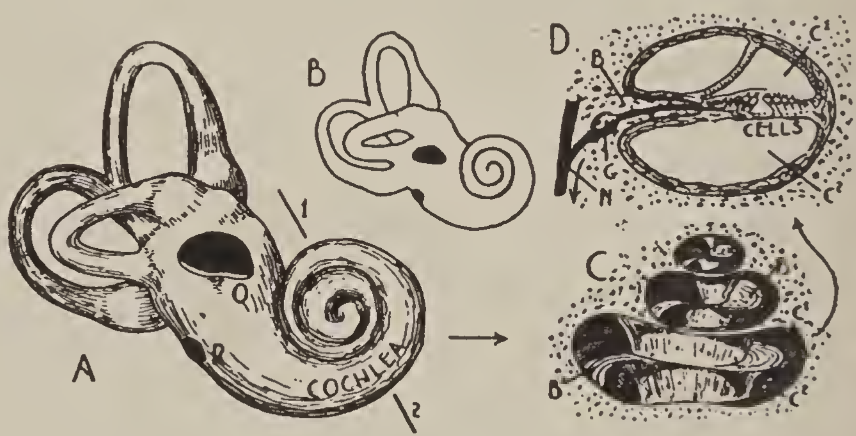


Fig. 236. The inner ear A, as removed from the skull; B, same, natural size; C, section of cochlea, through line 1-2; D, a canal (c) of C, more enlarged.

The canals are filled with a liquid, a kind of lymph. The way the sound waves are made to stimulate the hearing cells is interesting. The air waves strike the tympanum and set it in vibration; this causes the hammer, anvil and stirrup to vibrate. The stirrup knocks against the "oval window" (O, Fig. 236) of the cochlea, setting in vibration the lymph in the canals; the waves of this liquid pass through one canal to the top of the cochlea, then down the other and finally die out when reaching the end of the canal at the "round window" of the cochlea. (R, Fig. 236.) This principle is shown in Fig. 237, which rep-

resents the cochlea uncoiled and stretched out. The arrows indicate the path of the waves. When the lymph is in motion in the canals, it rubs over the hairs of the hearing cells (D, Fig. 236) and starts impulses that are carried to the brain by the auditory nerve fibers and there interpreted as sound.

The semi-circular canals are not used in hearing, but they have an important use in that they act as spirit levels and inform us (unconsciously, however,) when we are about to fall over. They, too, are filled with a liquid and their walls contain cells with projecting hairs. In these cells certain fibers of the auditory nerve end. When the body or the head is moved in any direction the liquid moves in one or the other of the canals. Of course, in the daytime a person can see with his eyes what position he is in, or he can see when he is about to fall over; but with the semi-circular canals he feels it much more quickly and can, by reflex action, right himself at once.

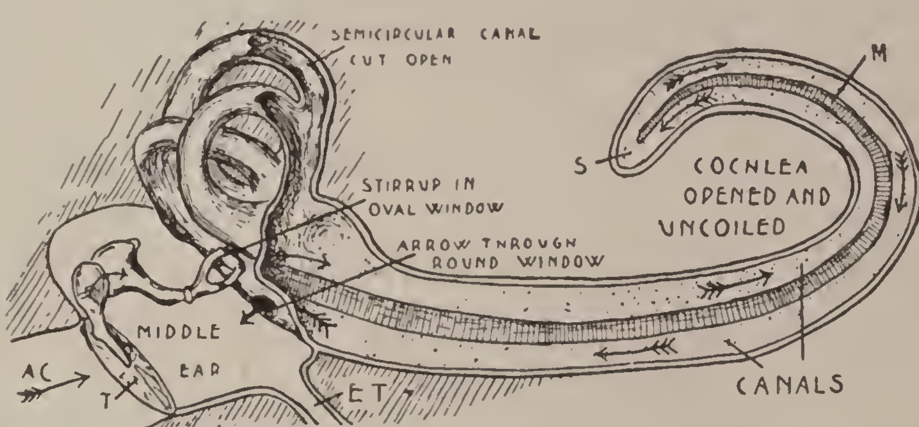


Fig. 237. Diagram showing passage of waves of sound through the ear; AC, auditory canal; T, ear drum; ET, Eustachian tube.

Summary.

The stimuli from the outside that cause us to hear are waves or vibrations of air. These are collected by the outer ear and directed to the ear-drum, which is thus made to vibrate. The sound waves are carried across the middle ear by a series of

three ear bones, the inner one of which, the stirrup, knocks against the opening of the inner ear. It is in the cochlea of the inner ear that the auditory nerve reaches the end cells that catch up the waves of sound. These cells are upon the partition of the spiral canal which winds around the cochlea. The wave travels in the liquid with which the cochlea is filled to the top of the cochlea on one side of the partition and comes back on the other side. As it travels through the cochlea it stimulates the end cells to which the auditory nerve fibers are attached. The impulse is carried to the brain, and thus we hear.

The semi-ciruclar canals also contain a liquid and end cells with nerve fibers. The canals are so placed that whenever we change our position the liquid in one or the other of the canals moves. The canals thus help us to maintain the balance or equilibrium of the body.

Questions.

1. What is air composed of? (Chapter XXVIII) 2. How are sound waves produced? 3. Name the divisions of the ear. 4. Name the parts of the outer ear and tell the function of each. 5. What separates the outer from the middle division? 6. How may the ear-drum be injured? 7. How is it protected? 8. How does the middle ear communicate with the outside air? 9. Why is this so? 10. How do sound waves cross the middle ear? 11. Name the two parts of the inner ear. 12. Which of these functions in hearing? 13. Where are the end cells of hearing? 14. How do the sound waves reach these cells? 15. Where do the impulses pass from these cells? 16. What is the use of the semi-circular canals?

CHAPTER XLIV.

Sight.

In the sense that the ears are the organs of hearing the eyes are the organs of sight. As the ears are so constructed as to receive stimulations of sound waves and start these stimulations to the cerebrum, so the eyes are so built as to receive from light waves stimulations that are passed on to nerves going to the cerebrum. Sound waves are vibrations of air, and without air there could be no sound. But light travels far beyond the limits of the atmosphere, for it comes to us from the sun, moon and stars. Air seems to us to be very light and thin, but it is really very heavy and dense when compared with the substance that carries light. This substance is called **ether.** It pervades all space and waves of ether are **light waves.** Although we cannot see the waves of ether we must imagine them to be like the waves rippling across the surface of a pond of water. The eye has end-cells, sensitive to these delicate waves of ether, and branches of the nerve of sight **(optic nerve),** to carry the impulse to the brain. In this chapter we shall study how we see.

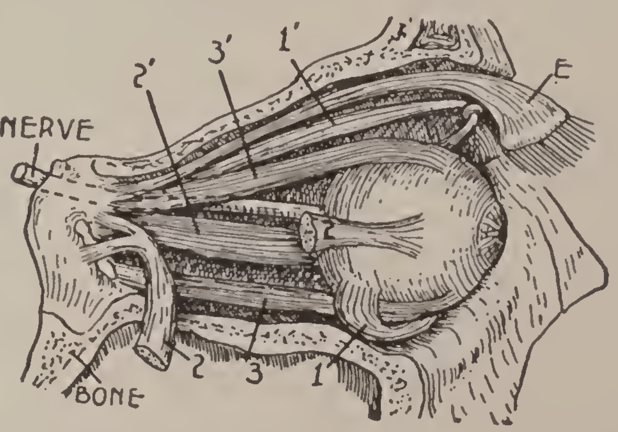


Fig. 238.—The muscles that move the eyeball.

Protection of the Eye.—The eye cannot be put away inside the bones like parts of the ear, but it, too, is protected. It is

set back in an orbit or hollow of the skull (Fig. 183), so that a fall or a blow on the face will not injure the eye. Again, two flaps of muscle, the **eyelids**, can be pulled over the eye to protect it against objects flying toward the face. (Study the action of the eyelids from the standpoint of reflex action, page 278). The eyelids are aided in their work of keeping out dust and dirt by protruding hairs on their edges, the **eyelashes**.

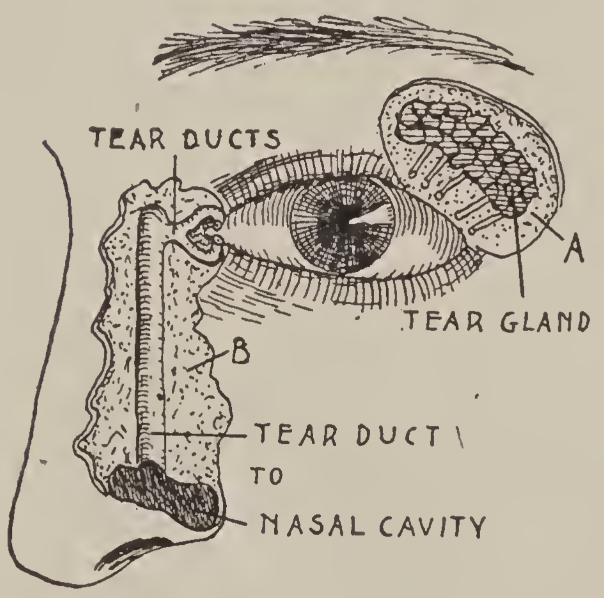


Fig. 239. The tear gland of the eye.

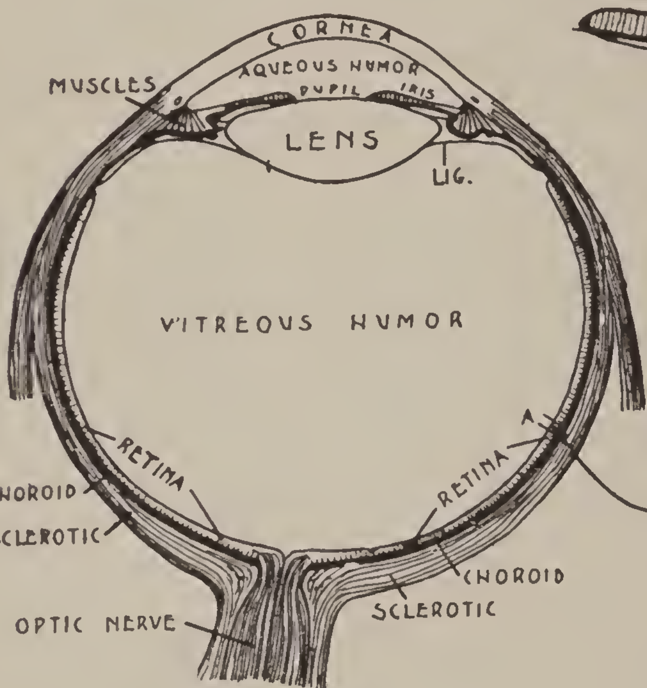
You have noticed that persons and animals wink at intervals. The purpose of this is to distribute over the eyeball a fluid secreted by the tear glands, for the surface of the eyeball must be kept moist. The tear glands lie along the outer side of the eye and the tear is emptied on the under side of the upper eyelid. (Fig. 239.) The tear is usually carried off by certain tear ducts that lead to the nose; only in weeping do the eyes "overflow." The secretion of the tear glands is regulated by nerve fibers from the cranial nerves and, as you would expect, from the sympathetic system. One of the two openings of the tear duct can be seen in the center of a little elevation or papilla on the edge of the lower eyelid, near the inner corner of the eye. That the tears do not always run over the edge of the eyelid is due to the fact that there is a row of **oil glands** which empty their fatty secretion on the edge of the lid, thus preventing the tears from running over. During sickness these

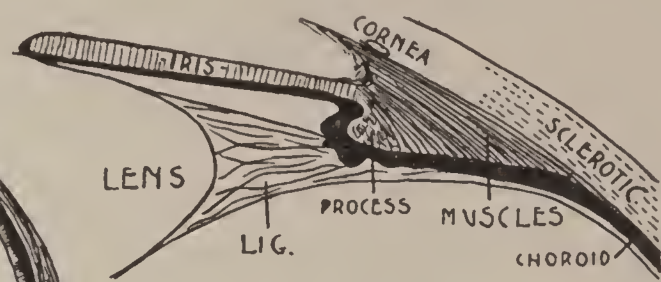
glands secrete too large an amount of oil, which, on drying and becoming hard and yellow, may glue the eyelids together.

Observation and Practice Work.—Using a mirror find the papilla on the lower eyelid as described above. Pull the eyelid down a little and the papilla with the opening to the duct will come to view. Make a drawing of the eye with the eyebrows, lids, eyelashes and other parts. Name them in the drawing.

How the Eyeballs Are Moved.—Looking at a sheet of paper

FIG. 240 FIG. 241





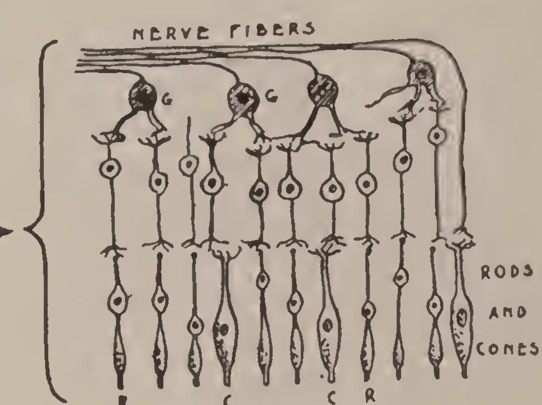


FIG. 240 FIG. 242

Fig. 240. Section of the eyeball with parts named.
Fig. 241. A part of Fig. 240 enlarged, to show attachment of lens.
Fig. 242. The part A of the retina in Fig. 240, much enlarged to show the "seeing" cells of the retina.

you will notice that, without turning the head, you can glance from the center to the right and left edge, to the top and bottom edges and to the corners of the paper. It takes six muscles (three pairs, Fig. 238,) to move each eye, and it takes three cranial nerves to supply these muscles and to regulate

their action. The two eyes move together, since the motor nerves send branches to corresponding muscles of each eye.

The form and inner structure of the eye can best be described with the aid of diagrams. The eyeball is almost spherical in shape, bulging a little in front, as shown in Fig. 240. The supporting layes of the eyeball are two in number: the outer or **sclerotic** coat, and the inner, or **choroid.** The "white of the eye" is a part of the sclerotic, as is also the transparent **cornea,** through which the black pupil and the colored iris can be seen. The choroid contains dark pigment so as to darken the inside of the eye; for the eye is a miniature camera or kodak, a dark box with only a small opening in front for the light to enter. This opening is the **pupil,** which is surrounded by a colored ring, the **iris,** a part of the choroid coat. A person's eye is said to be blue or brown if the iris is blue or brown. The iris regulates the amount of light to be admitted to the eye. In bright light the pupil is small (Fig. 244); in the dark the pupil is large (Fig 243). There are muscles in the iris that regulate the size of the pupil, and these muscles are regulated by cranial and sympathetic nerves. Their action is reflex and involuntary.

Figs. 243 and 244. The pupil of the eye, large and small.

Observation Work.—At night, examine the size of the pupils of the eyes after having been in the dark for some time. Then examine them after having been in the light, perhaps looking at a white sheet of paper for ten or fifteen minutes. (See Figs. 243 and 244.) Examine a cat's eye at night and again in the daytime.

The Lens.—Immediately behind the iris is the **lens.** This is a most important organ in enabling us to see clearly and is to the eye what the glass lens is to the camera. The eyeball is filled with a clear watery fluid (the **aqueous humor,**

Fig. 240) in front of the iris, and with a clear, jelly-like mass **(the vitreous humor)** behind the lens.

The Retina.—Waves of light enter the pupil, pass through the lens and are distributed over the inside wall of the eye. Where, then, are the sensitive cells and their nerve fibers that catch up the light waves? These cells are located in a coat of the eye called the **retina,** inside of the choroid. (Fig. 240.) This layer of sensitive cells occupies a position similar to that of the sensitive film or plate in a camera. There are, consequently, three coats of the eyeball: the sclerotic, mainly for support; the choroid, mainly to absorb the excess of light, that is, to make the eyeball dark inside; and the retina as the layer sensitive to light waves. Fig. 242 represents a section of the retina, much enlarged. The sensitive cells are "rods and cones," (so called from their shape) and stand pointing toward the choroid layer. More or less closely connected with these are nerve fibers from the optic nerve. (Fig. 210.) Light waves strike the rods and cones and cause nerve impulses in the fibers of the optic nerve. These, on reaching the nerve cells of the cerebrum, cause the sensation of sight.

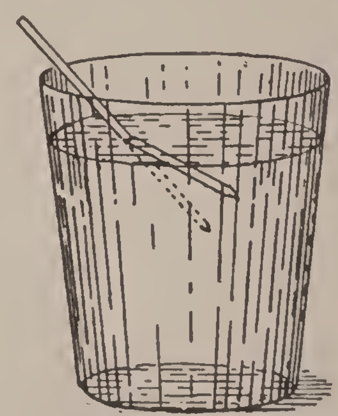
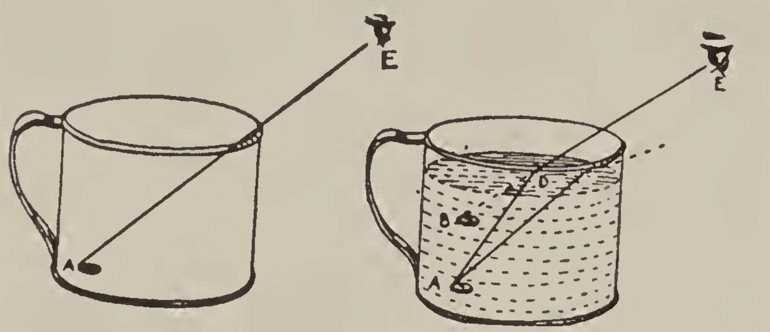


Fig. 245. A pencil looks bent or "broken" when immersed in water.

The Refraction of Light.—Rays of light tend to travel in a straight line. But when, after passing through air, they strike the surface of water or glass or the transparent parts of the eye, the rays are bent suddenly out of their course. We say they are broken, or **refracted.** This refraction can be illustrated by the following experiments:

Experiments on Refraction.—(1) Place a pencil into a tumbler of water and note that the pencil looks broken, as shown in Fig. 245. (2) Into a tin cup place a coin and have ready a quantity of clear water. Place the eye as shown in Fig. 246, so that the coin will be just out of view. Now cautiously pour water into the cup. Note that the coin gradually comes into view as the water level rises. Fig. 247 gives the explanation of this. Rays of light between the bottom of the cup and the eye (E) are refracted at the surface of the water, A, where water and air meet, as, for example, ray ADE. Therefore the coin, A, is in full view, although not in direct line, and seems to be raised above the bottom of the cup, as at D. (3) To show how a lens refracts the rays of light, hold a glass (a magnifying glass or a convex lens from a pair of spectacles) in the sun, using it as a "burning glass." The rays of sunlight are refracted by the lens and turned together to a focus.



Figs. 246 and 247. An experiment in refraction. (See text.)

How the Image Is Thrown Upon the Retina.—The rods and cones that catch up the rays of light are very tiny. In order to see sharply and clearly a single rod or cone must receive the light from a single tiny point of an object. To make clear how an image is formed on the retina we may begin with a simple thing, for instance, a small spark the size of a period used to punctuate this page. The spark gives off rays of light in every direction, for it can be seen from all sides. But only those rays would reach the retina which pass through the pupil. Thus of all the rays of light represented in Fig. 248, which radiate from the spark (S), only

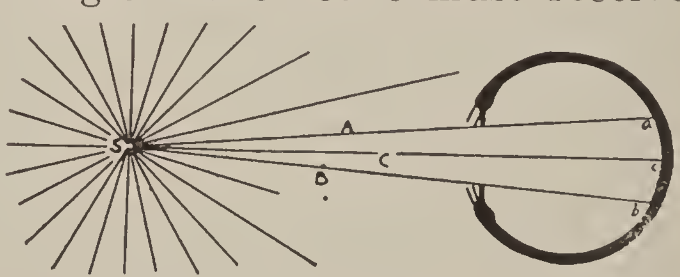


Fig. 248.—The rays of light from a single point would be scattered over the retina if there were no cornea or lens.

A, B and C reach the retina. Now, if the light rays would enter the eye unobstructed (as represented in Fig. 248) the rays A, B and C would strike the retina at a, b and c. So with all other rays between them. There would be so many images of the spark on the retina that we would see the spark as a large round spot. Of course, if the pupil were made so small that only ray C could enter, there would be but one image, c; but this would not be bright and strong. It is, therefore, desirable that all of the rays that strike the eye in front of the pupil (A, B and C) should fall on one point, c, as in Fig. 249. This is brought about by the convex surfaces of the cornea and the lens which refract the rays and turn them together to a point or focus on the retina (c, Fig. 249.) Collecting the rays of light and bringing them to a focus is called **focusing**.

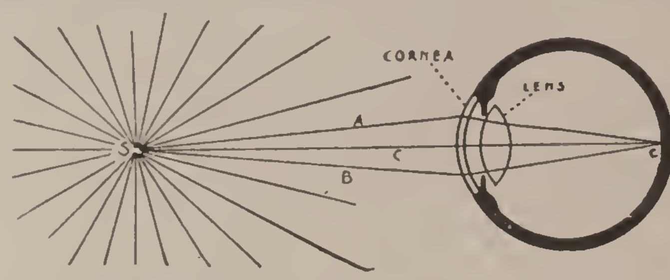


Fig. 249. The cornea and the lens focusing rays of light to a point.

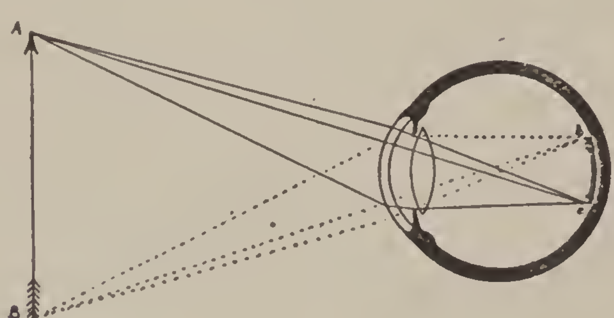


Fig. 250. Every ray of light from any one point of an object is focused on the retina. This causes a clear image of the object to form on the rods and cones of the retina.

So it is with all the many rays of light that pass out from every object. In Fig. 250 the rays from the point A, on the head of the arrow, are focused on point a of the retina; those from point B on the feather of the arrow are focused at b on the retina. Each part of the arrow is thus clear-cut on the retina. The images of objects are thrown on the retina inverted. In order, then, that the image of the object may be

clear, the cornea, the lens and the entire eyeball must be of the right shape. Such is the case in the normal eye.

Observation Work.—Look out of the window into the distance. Now hold up your hand in front of your face and continue looking into the distance between the fingers. The hand is not seen clearly —it is blurred. Again, hold your finger one foot from your face between your eyes and the landscape. Look at your finger. If you see the finger in clear outline the objects of the landscape are blurred. This is due to the action of muscles changing the shape of the lens, as will be noted below.

Accommodation.—As shown in the experiment just made there must be something in the eye which must be "set" for

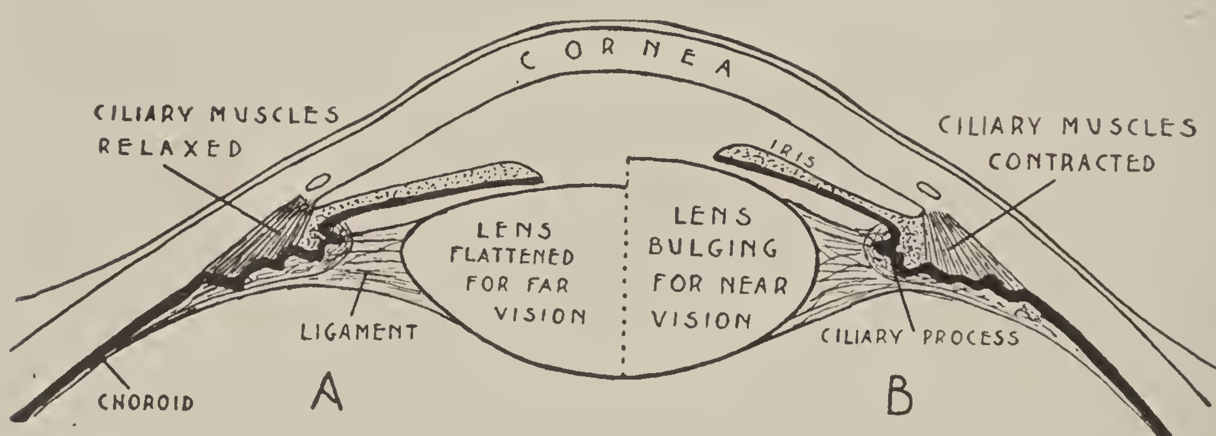


Fig. 251. Diagram to show the lens is changed for far or near vision.

seeing far or near. That "something" is the lens, which "accommodates" the eye for far or near sight. For seeing near objects, the lens must bulge out in front, that is, it must be more convex. It is made so by muscular effort. Fig. 241, which is part of Fig. 240 more enlarged, shows that the lens is attached by a ligament (Lig) to a process (ciliary process) in the wall of the eyeball. The ligament is a complete circle, of course, and there is a whole circle of ciliary processes. Muscles (ciliary muscles) are so attached that when they contract, the ciliary processes are pulled toward the lens and the

ligament holding the lens slackens. The result is that the lens, being elastic, assumes a more convex form. (Fig. 251.) The lens is not stretched and flattened by muscular effort, as is sometimes thought, but made to bulge or thicken. When the ciliary muscles relax, the ligament of the lens resumes its pull and the lens again takes on the flatter shape for seeing at a distance. It is important to note that it requires muscular effort for seeing close by, as, for example, in reading and sewing. Study carefully Fig. 251.

Experiment to feel that muscular effort is needed for near vision—look into the distance. The lenses of your eye are now accommodated for far vision. The ciliary muscles are at rest. Now bring the finger up before the eyes and remove the attention from the distance to the finger, noting carefully the feeling in the eyeball as the accommodation to near vision is being made.

The Normal Eye.—In a normal eye (1) the eyeball is of the right shape; (2) the iris properly regulates the amount of light that enters the eye; (3) all of the parts through which light has to pass are transparent (name them); (4) the lens and cornea have a smooth, regular surface, without irregularities; (5) the lens is elastic, responding readily to the effect of the ciliary muscles, or springing back into the resting position.

The Defective Eye.—Common imperfections in vision are due to defects in regard to one or more of the points just enumerated. The image must come to a focus exactly on the retina (Fig. 250), or the image will not be distinct.

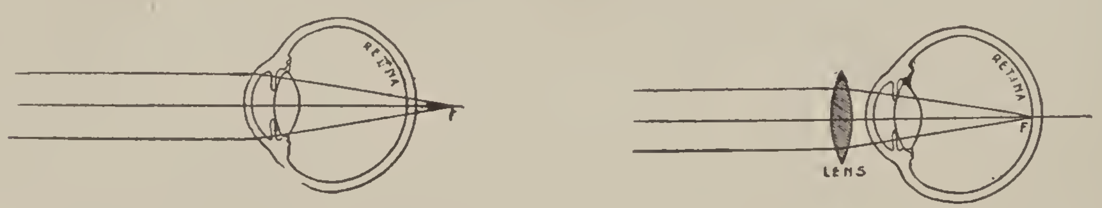
In near-sightedness the image comes to a focus before reaching the retina (Fig. 252), and the same rods and cones receive rays of light from different parts of the object, thus confusing the image and making it dim and blurred. Such an eye would be helped by concave lenses set into spectacles, for

such lenses would spread the rays of light and prevent their coming to a focus too soon. (Fig. 253.) Near-sightedness is usually due to the fact that the eye is too long, that is, the

Figs. 252 and 253. In short-sightedness the eyeball is too long. This may be overcome by a concave lens.

the distance from the cornea to retina is too great. (Fig. 252.)

Far-sightedness is due to the opposite cause from that of near-sightedness; it is due to the eye's being too short from cornea to retina. (Fig. 254.) In such an eye the image reaches the retina before the rays of light have been brought to a



Figs. 254 and 255. In far-sightedness the eyeball is too short. This defect is overcome by wearing convex glasses.

focus. A person suffering with far-sightedness should wear glasses with convex lenses, for these bring the rays of light together and help the lens of the eye to focus the rays on the retina. (Fig. 255.) The wearing of spectacles is not a fad, but is based on scientific facts. Many headaches are due to imperfect eyesight that might easily be corrected with glasses.*

*Most old persons are far-sighted. The tissues of the lens become hardened and cannot be accommodated for clear vision. This is the reason that most older persons can use one another's glasses

Astigmatism is a defect of the cornea and the lens, in which either or both have irregularities or uneven places in their curved surfaces. This is a common cause of imperfect vision with children, and should receive prompt attention. A pupil poor in reading, but good in other studies, probably has something wrong with the eyes.

CARE OF THE EYES.

A study of the anatomy of the eye and the physiology of its parts enables us to study intelligently the hygiene of the eye.

Rest.—Since the ciliary muscles contract to accommodate the lens for "near work," such as reading or sewing, it is necessary that they be rested from time to time. This is, of course, easy to do by simply looking into the distance. This relaxes the muscles and has the same effect on them as "relaxation" has on the muscles of the arms and legs.

The size of type used in printing the matter which you read is an important consideration. If the type is too small the strain on the eyes is very great. It does not pay to purchase even a cheap book with poor type. The size of the letters in the Primer and first reader used in your school is probably the best size for a beginner. This book is printed in clear type of the right size for most people.

The Intensity of the Light.—For reading or other close work with the eyes the light should be neither dim nor very

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with comfort. Look at a printed page through an old person's spectacles and you will see how the page looks to the person when not using his glasses; you will also get an idea of what is meant by a blurred image.

bright. If too dim the pupil of the eye becomes so large as to cause the letters of the printed page to be less clear and distinct. It is a great mistake to read at dusk without artificial light. Neither should the light be too bright. If your eyes are strong now you are fortunate and should not neglect their care.

Direction of the Light.—The best rule to follow is to have the light pass **over the left shoulder** on to the printed page. **Never should the light come from the front.** In a school room the front windows, if there be any thus wrongly placed, should be darkened. The main light should come from the left. The windows should be placed high, even touching the ceiling, for it is the light **from above** falling **on** the desks which is best in the school room. If shades are needed to keep out the direct rays of the sun, they should be of the adjustable kind, so as to allow some light to enter from the top if possible.* Shades pulled down on a sunny day should be raised on a cloudy day. Watch your school room and keep the lighting right. When reading by artificial light do not allow the light to shine directly into the eyes. It is well to shade the light or to place a shade over the eyes to protect them.

Steady Light.—A flickering light, such as that of a candle, or a simple gas jet without a mantle, is hard on the eyes. Reading on trains should also be avoided.

Spectacles.—It has been explained how spectacles correct the defects in vision caused by abnormally long or short eyeballs, by irregularities of the cornea or lack of elasticity of the lens. Many pupils are backward in school on account of defects in vision, which could easily be corrected by the use of

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*See footnote, page 203.

glasses. Teachers should be on the lookout for such cases and parents should consult a competent oculist concerning the child's eyes when there is the slightest suspicion of optical defects.

Cinders in the Eye.—The eyeball is covered and the eyelids lined with a very delicate membrane easily injured. The presence of hard, sharp particles, such as cinders or sand-grains, irritates this membrane and causes inflammation of the eyeball and of the lid. The foreign particles should be removed with the corner of a clean handkerchief. Disease germs are also likely to enter the eye and cause inflammation. The eye should not be rubbed with the fingers, as by this means germs are often transferred to the eyes.

Trachoma (also called granulated lids) is the worst communicable disease that affects the eyes. It is not very common in this State, and yet it is fairly well distributed over the different counties. It causes sore eyes, and later, scarring under the lids, so that they pucker up and do not fit the eyeball. The cause of trachoma is not known, but we do know positively that it is contagious. It is communicated by the matter or secretion from the eyes, but, of course, this matter must in some way get into the eyes of the new victim. The disease may be spread by public towels or by pencils borrowed from children that have sore eyes. When we have as many gnats and flies as we had in 1902, these may light on the eyes of one individual, pick up a few drops of the infected fluid, and carry it to the eyes of another individual. For this reason, as well as for many others, our houses should be screened to keep the insects out.

The ordinary "**sore eyes,**" which merely causes the eyes to stick together for a few days, is another contagious eye disease which is called "pink-eye." This is carried from one

child to another in the same way as the trachoma. In 1902 there was an epidemic of this disease in Texas due to the gnats and flies. We do not often have so many insects as we had in 1902, but we have the public towel with us at all times, and we should be on our guard against that. A good substitute for it is the sanitary paper towel, which can be bought at about one-fourth cent each. (Fig. 181.)

Summary.

The eye, or seeing organ of the body, may be likened to a camera. Like the camera, the eye is a dark box, the choroid coat serving the purpose of the black paint in the camera. There is an opening, the pupil in the eye, to admit the light. The size of this (and thus, the amount of light entering the eye) is regulated by the iris. The sensitive film is the retina, containing the rods and cones, which are the sensitive end cells, or "seeing cells," connected with fibers of the optic nerve. There is, too, a clear convex lens, which, with the clear convex surface of the cornea, serves to focus the light rays on the retina as the glass lens of the camera focuses the light on the sensitive film.

For far and for near vision a different focus is required. This change of focus is brought about by a change in the convexity of the lens. When the ciliary muscles contract they bring the ciliary processes nearer the lens, thus allowing the elastic lens to bulge out. When the muscles relax the lens is brought back to the flatter shape. We can rest the eye from continued close work by occasionally looking off into the distance. Short-sightedness, far-sightedness and astigmatism are common defects in vision, due to the imperfection of the focusing apparatus of the eye. They may be corrected by wearing the proper glasses.

We should take the best of care of these wonderful organs, the eyes. We should be observant about the direction and the quality of the light. We should not touch the eyes with our fingers or with unclean objects for fear of transferring germs to the moist, delicate membrane covering the eye.

Questions.

1. What are sound waves? 2. Light waves? Why cannot the eye be put away in the skull bones as is the inner ear? 4. How is the eye protected against blows? 5. Against dust? 6. Against drying out? 7. How are the tears ordinarily kept from flowing over the edge of the eyelids? 8. Point to your own tear glands. 9. Why do we have to blow our noses when we begin to cry? 10. How many muscles move the eyeball? 11. How many nerves are represented in Fig. 210 as passing to the eyeball? 12. From a section drawn on the blackboard after Fig. 240, point out the three coats of the eye. 13. What is the function of each coat? 14. From what part of Fig. 240 is Fig. 241 an enlargement? 15. How does the pupil grow larger and smaller? 16. Why does it change in size? 17. Why cannot owls see well in daylight? 18. Where is the cornea? 19. The lens? 20. The iris? 21. How is the lens held in place? 22. Why can we not see all the rays of light coming from a given point? 23. What is meant by refraction? 24. Describe two experiments to illustrate refraction. 25. Describe focusing. 26. Why do rays of light have to be focused on the retina? 27. How are they focused? 28. How is the eye accommodated for seeing near objects? 29. Draw Fig. 251 on the board and explain the use of all the parts shown. 30. How can you prove that it requires muscular effort to accommodate the eye for seeing a near object? 31. How can you rest your eyes at intervals when engaged in close work? 32. Mention the common defects of the eye. 33. Describe the near-sighted eye. 34. The far-sighted eye. 35. Why do people usually become far-sighted with age? 36. What is astigmatism? 37. What can we do for these common optical defects? 38. What can you say as to the intensity of the light in reading and sewing? 39. The direction of light? 40. How may contagious diseases of the eye be avoided?

CHAPTER XLV.

Accidents and Emergencies.

It is not often that accidents occur when we are expecting them; this is only another way of saying that we are usually unprepared when accidents occur. It is possible, however, for us to prepare ourselves to a certain extent, so that we shall not be entirely helpless in the face of emergencies or sudden happenings.

Examination of the Injured Person.—The first thing to do when anyone is injured is to look him over and see whether he is losing blood and whether he is getting his breath. If he is not bleeding very much, and is breathing, we may rest assured that there is no pressing need for immediate action.

Severe Hemorrhage.—If, however, the injured person is bleeding profusely, something must be done at once. In case of large hemorrhage, that is, if the patient is bleeding as much as a teacupful every minute or two, it is absolutely necessary to stop the hemorrhage on the spot. There is no time to hunt up medicines, or clean bandages. Under these circumstances, the cleanest cloth that can be found must be pressed into and around the wound. If it be pressed tightly, with all one's strength, it will staunch almost any hemorrhage. After the bleeding is hurriedly stopped, or at least diminished in this way, it is time to look around for some more satisfactory way of keeping down bleeding till assistance can arrive. Sometimes it is necessary to hold the fingers pressed into a wound for an hour till the surgeon can reach the patient. If the

hemorrhage is from an extremity, that is, from an arm or leg, a tight bandage, such as a handkerchief wrapped around the limb, between the wound and heart, will stop the bleeding. A tight bandage should not be left on a limb for more than half an hour or it may cause gangrene.

Trifling hemorrhage should be stopped by placing a clean white cloth over the wound and making gentle pressure. Usually, binding the cloth onto the wound will prevent a return of the hemorrhage.

Cuts and other open wounds should not be washed with water unless the water is pure. Boiled water is always free from germs. A reliable antiseptic or disinfectant should be applied to wounds of this character, and they should be covered with clean white cloths, preferably cloths that have been boiled and dried without being handled. Disinfectants have been described in Chapter XVI. Usually it is not wise to employ a solution of carbolic acid as a permanent dressing, unless the acid and the water are mixed thoroughly; and it takes a good light to decide the question. Gangrene has been produced in numerous instances by dressing wounds in moist carbolic dressings.

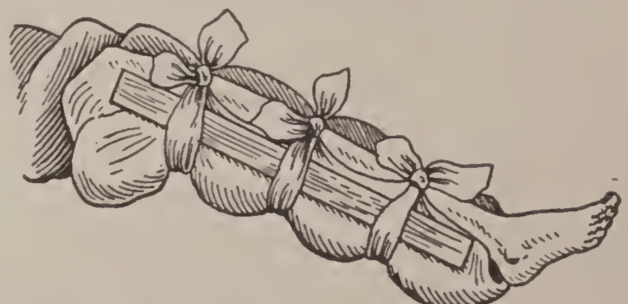

Fig. 256. A pillow and two boards make a good temporary brace of splint for a broken limb. The pillow is made into a trough, the limb is placed in this trough, and the boards are adjusted and held in place by several handkerchiefs or other bandages.

Broken bones are painful, and may in certain cases be dangerous. The worst thing that can happen after a fracture has occurred is for the bones to protrude or stick out through the skin. When they do so, they are likely to become infected by germs, especially the tetanus or lockjaw germ. The bones should therefore be handled carefully to avoid opening the skin. The picture shows

a pillow-splint that can be applied when no surgeon is at hand. This splint is suitable for fracture of arm or leg.

Tetanus or Lockjaw.—The tetanus or lockjaw germ is one of the worst germ enemies we have, and it would pay us well to study it. This germ lives outside the body oftener than inside. It is not like the typhoid germ, which refuses to multiply except in the human body. The tetanus germ lives in the ground, especially around gardens and horse lots. It practically never harms the human body except when introduced through an open wound. So far as we know, swallowing

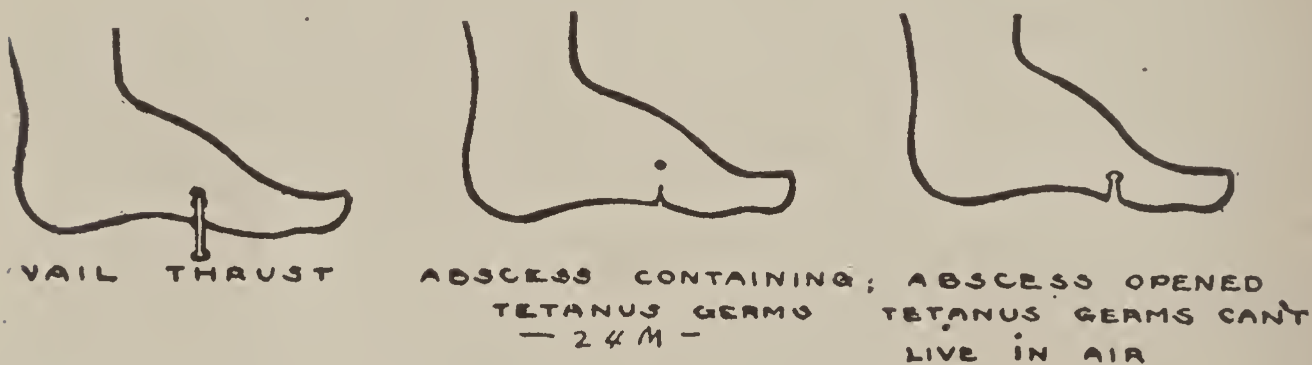

Fig. 257. The middle picture shows how the tetanus germs are closed off from the air when the skin heals too rapidly. The only safe thing to do is to open up the abscess and let in the air.

the tetanus germ never hurts anyone. The fact is that the tetanus germ cannot live in the air; it has to be shut off from the air. Supposing that the wound has been made by a rusty nail, after the skin swells a little and closes the hole made by the nail, the germ is down under the human skin, and is shut off from the air. You have noticed that healing of the skin often occurs, even though there are germs and pus down deep under the skin.

Tetanus Is Almost Incurable.—A remarkable thing about this disease is that after it once develops the doctors can do very little toward healing or curing it. Lockjaw causes the most terrible spasms all over the body. The locked jaws are

the least part of the disease. **If we are to save one's life after he has thrust a nail into his foot, we must act before the disease develops.** Usually it takes tetanus about a week or ten days to develop after the wound is received. The proper treatment is to open up the wound and let the air get down into the depths of it. This is shown in Fig. 257. If there is any doubt about the air getting entirely into the depths of the wound, tetanus antitoxin should be given. If these precautions are neglected, and if the tetanus once appears, all the powers on earth cannot with any certainty prevent death. Over three-fourths of all cases of tetanus die. The antitoxin is good for prevention, but cannot be relied upon to cure after the disease once develops.

All Narrow and Deep Wounds Are Dangerous.—From what has been said, you can see that all narrow deep wounds are especially dangerous, because the skin closes up and shuts out the air, making it possible for the tetanus bacterium to live. Powder burns made by the little toy pistols and by firecrackers are deep wounds, and often cause lockjaw. They should be carefully treated early, before it is too late. Splinters also make narrow deep wounds and are likely to cause lockjaw.

Snakebites strike terror to the hearts of many persons, but this is not so much due to the actual danger from the bite as to man's instinctive horror of snakes. As a matter of fact, the number of deaths occurring in Texas from snakebite is very small. In case one is bitten by a snake, unless he knows that the bite was inflicted by a harmless variety, it is well to proceed as follows: If the wound is on a leg or an arm, as is likely, quickly throw a tourniquet or bandage that can be twisted tight around the limb between the wound and the heart. A handkerchief serves well for a bandage; out in the woods some twigs of tough plants will do. After bandaging,

to prevent the blood from carrying the poison toward the heart, take a knife and sterilize the blade of it by flaming it with a match. Then make an incision over the wound of the snake's fangs, cutting two cross marks each a quarter of an inch deep. Squeeze out as much blood as possible up to the amount of a wineglassful, but no more.

You can always tell whether your treatment is effective or not, for, if ineffective the patient will become weak and pale in less than half an hour. This can be corrected by giving him a teaspoonful of spirits of camphor in half a teacupful of water. The tight bandage need not be kept on longer than thirty minutes in case no symptoms of weakness arise; but if they do, and the bandage is kept on longer, it should be removed for one minute every twenty minutes.

A word of caution is here needed about the use of alcohol. Whiskey should not be used in case of snakebite. The medicine to take along when on hunting and camping trips for snakebites is potassium permanganate. A strong solution of this in water is poured into the crossed incision described above.

There are only a few poisonous snakes in Texas. The worst and most common are: the rattlesnake, which is familiar to most people the world over; the copperhead, which is a dull-mottled snake, having a blunt tail, and is found in dry upland fields; and the cotton-mouth moccasin, which has a blunt tail and is white under the chin, and lives in streams and ponds. The prairie runner or coachwhip, the chicken snake and the garter snake are harmless.

Fainting.—There are few accidents that excite the bystander more than fainting. When the fainting person falls, let him lie but see to it that he has plenty of fresh air. Fanning the patient is helpful, as is also the inhalation of lavender salts.

The customary dash of cold water in the face is also good. Recovery from a fainting spell usually takes only a few minutes.

Burns.—Women and girls are especially in danger of getting burned because of their loose clothing, and also because of their duties in the house and around the fire. In 1911 there were 39 women accidentally burned to death in Texas.

The most important point to keep in mind about burns is how to avoid them. Burning is a form of accident for which very little can be done before the physician arrives. It is well to keep unclean articles from touching the raw surfaces of the burn. It is not well to put water on large burns. The dead skin should be left in place until the doctor comes.

Common Causes of Burns.—Burns are usually, though not always, the result of carelessness or ignorance with regard to the nature of coal-oil or kerosene. Never start a fire with kerosene oil! The oil is so easily touched off that the slightest spark is sufficient to do so. Furthermore, when it once starts to burn in an open place like a stove it burns with such violence that burning oil is thrown about.

Smothering Flames.—Everyone knows that when flames are fanned they burn more strongly. Therefore, when a person has caught fire he or she should be prevented from running wildly about. If no water is at hand in sufficient amounts, the flames may be smothered by throwing the burning person to the ground and piling on him or her rugs, blankets and similar articles that may be handy.

Artificial respiration means making a person breathe when for any cause his natural breathing movements have stopped, as, for instance, when he has been shocked badly by electricity, or when he has been under water and almost drowned. The best method of giving artificial respiration is a method

which may be used by one person alone, and is illustrated by Figs. 258 and 259. The injured person is placed face down, and his head turned slightly to one side so as to keep the mouth out of the dirt. If possible, the head should be turned down hill. The person who gives the artificial respiration sits across the hips of the injured one, as shown in the picture, and places his hands on the other's back and lower ribs. By alternately pressing and releasing pressure with the hands, fifteen times to the minute, air is first pressed out and then drawn into the lungs. This method of artificial respiration is especially good for the reason that the tongue does not fall back and stop up the throat, because the patient is lying on his face. In the older methods two persons were required, because the patient was on his back and his tongue had to be held forward by a second person. The movements in artificial respiration should never be forcible enough to injure the lungs, and as soon as the patient shows signs of gasping an attempt should be made to cause exhalation when he is trying to exhale. Of course, it would be unwise to make pressure on his chest when he were trying to inhale.

Fig. 258. First position in giving artificial respiration.

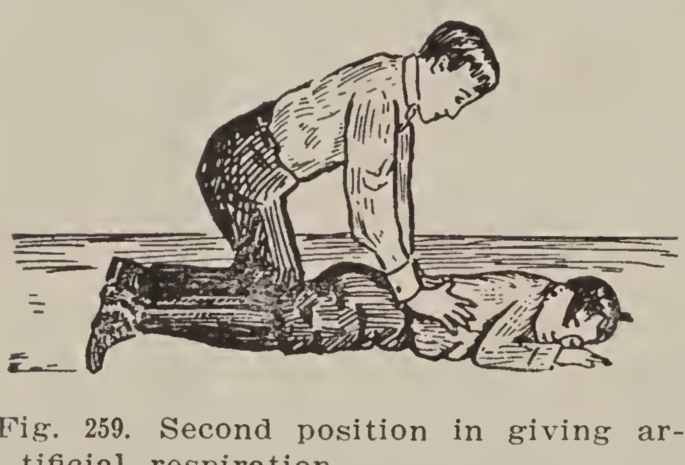

Fig. 259. Second position in giving artificial respiration.

Important Points.

1. If the injured one is breathing, and if he is not bleeding, there will not be any need for unreasonable haste.

2. If he is bleeding very rapidly, anything clean pressed into and around the wound will stop the bleeding till you can do something further.

3. Do not wash cuts with water unless the water has been boiled, and do not touch the cut with anything except a clean cloth.

4. To avoid burns, do not take a large vessel full of oil near a stove; do not pour oil into a warm stove; and do not try to fill a lamp while it is lighted.

5. To put out clothing that has caught on fire, throw the burning person to the ground and smother the flames with a wet or dry blanket or other cloth.

6. Nail thrusts are dangerous and should be opened up thoroughly to let in air and prevent the growth of the tetanus or lockjaw germ.

Questions.

1. When is bleeding dangerous? 2. What is one sure way to stop bleeding? 3. Why is it unwise to wash a fresh cut? 4. Give two common causes of burns. 5. What accidents are likely to produce lockjaw? 6. Out on a ranch, what would you do if a friend were bitten by a large rattlesnake? 7. Would you prop up a person that has fainted or let him lie horizontally? 8. How do you give artificial respiration?

APPENDIX A.

Sanitary and Unsanitary Outhouses.

In the State of Texas there are a good many of that class of boys who believe in carrying into effect what they learn. Many of these boys are Boy Scouts. For these energetic and intelligent young men the following directions for making a sanitary privy, such as the one shown in Figs. 262 to 264 are given:

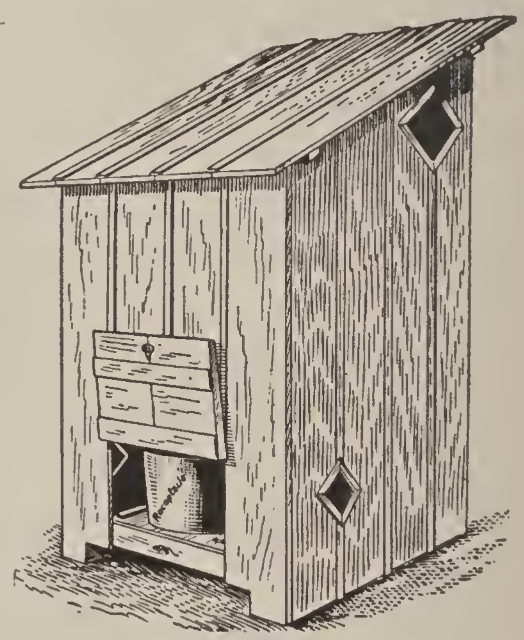

Fig. 262. When the lid is dropped, flies can not reach the receptacle or tub.

To begin with, we should recall that the three things necessary in closets are as follows: First, flies must be excluded absolutely; second, the closet must not overflow and drain into the well; third, the waste matter or night-soil, as it is called, must not flow out where it can be stepped on by barefooted boys, who might in this way get hookworm. Many boys will find that they can modify the water-closet which they already have so as to make it fulfill all these three requirements. For instance, a few yards of wire screen well placed will exclude flies with absolute certainty. A water-tight tub or other vessel can be placed underneath to catch the waste materials, and this tub must be emptied at intervals of a week or two. It should be treated with some disinfectant each day or two: probably the coal tar disinfectants referred to in Chapter XVI are the best.

For making an entirely new closet (and this would better be done where there is any doubt at all about the possibility of fixing up the old one) order the following materials: One piece 6x6 inches, 8 ft.

Fig. 263. Notice the screened windows or ventilators, and the trap-door on the seat.

long. One piece 4x4 inches, 16 ft. long. Five pieces 2x4 inches, 16 ft. long. Three pieces 1x6, 16 ft. long. Two pieces 1x9 inches, 9 ft. long. Three pieces 1x10 inches, 7 ft. long. Fifteen pieces 1x12 inches, 12 ft. long. Twelve pieces 1-2x3 inches, 16 ft. long. Two pounds 20-penny spikes. Six pounds 10-penny nails. Seven feet screen, 15 mesh, galvanized or copper, 12 inches wide. Four hinges six-inch strap. Two hinges six-inch "T" or three-inch buts for cover. One coil spring for front door.

Having got this material ordered and delivered, cut the scantling as follows:

A—Two pieces of lumber 4 feet long and 6 inches square at ends.

B—One piece of lumber 3 feet 10 inches long; 4 inches square at ends.

C—Two pieces of lumber 3 feet 4 inches long; 4 inches square at ends.

D—Two pieces of lumber 7 feet 9 inches long; 2 by 4 inches at ends.

E—Two pieces of lumber 6 feet 7 inches long; 2 by 4 inches at ends.

F—Two pieces of lumber 6 feet 3 inches long; 2 by 4 inches at ends.

G—Two pieces of lumber 5 feet long; 2 by 4 inches at ends.

H—One piece of lumber 3 feet 10 inches long; 2 by 4 inches at ends.

I—Two pieces of lumber 3 feet 4 inches long; 2x4 inches at ends.

J—Two pieces of lumber 3 inches long; 2 by 4 inches at ends.

K—Two pieces of lumber 4 feet 7 inches long; 6 inches wide by 1 inch thick. The ends of K should be trimmed after being nailed in place.

L—Two pieces of lumber 4 feet long, 6 inches wide and 1 inch thick.

Having got the lumber sawn into the right sizes, put it together as follows, referring to Fig. 264 as a model:

First lay down the sills marked A and join them with the joist marked B; then nail in position the two joists marked C, with their ends 3 inches from the outer edge of A; raise the corner posts (D and F), spiking them at bottom to A and C, and joining them with L, I, G, and K; raise door posts E, fastening them at J, and then spike I, in position; H is fastened to K.

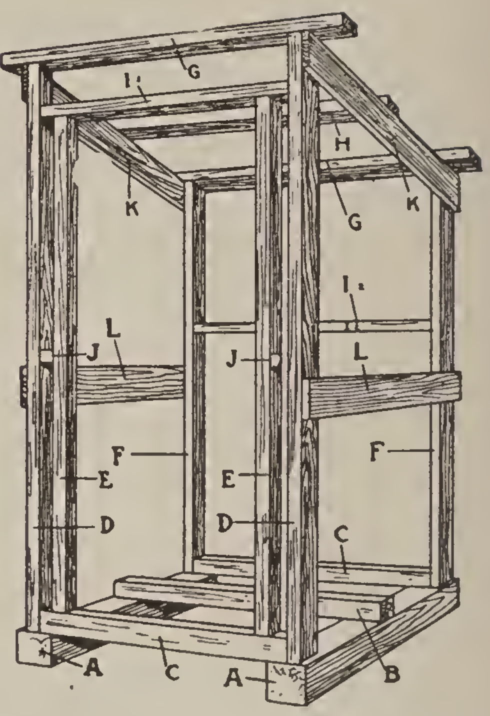

Fig. 264. This shows how to erect the frame for a sanitary closet; see instructions on this page and the page preceding.

After the frame is erected, the sides, floor, roof, seat, windows and doors can be built as shown in Figs. 262 and 263. These pictures and directions are borrowed from Public Health Bulletin 37, written by Dr. C. W. Stiles and issued by the U. S. Marine Hospital Service. The bulletin may be had by writing to the service at Washington, D. C. Somewhat fuller instructions will be found in the bulletin than in this chapter.

APPENDIX B.

Abstract of the Sanitary Code for Texas.

[Note.—The Sanitary Code for Texas is important; it not only has a bearing on the everyday life of each citizen in that it must be obeyed, but it also has great educational value, for it expresses the judgment of Texas Sanitarians and Legislators, as to the wisest method of combatting preventable disease. There are many valuable rules in the Sanitary Code which are not familiar to the citizens; some of these rules need to be invoked in time of epidemic, but others should be enforced every day to protect the public against such common dangers as tuberculosis and typhoid fever, which in Texas, as elsewhere, are prevalent at all times. Again, some of the rules of the Code relate to schools. These have been printed in black-faced type, and will be of service to teachers and trustees.]

Rule 1. Any physician in Texas who is called in to treat a person sick with any contagious disease is required to notify immediately the local health authority.

Rule 2. By "local health authority" is meant the city or county health officer or the local board of health.

Rule 3. The following are considered as contagious diseases: Asiatic cholera, bubonic plague, typhus fever, yellow fever, leprosy, smallpox, scarlet fever (scarlatina), diphtheria (membranous croup), epidemic cerebro-spinal meningitis, dengue, typhoid fever, epidemic dysentery, trachoma, tuberculosis, and anthrax.

Rule 4. The local health officer is required to keep a record of all contagious diseases reported to him, and to make a monthly report of these cases to the State Board of Health. The records of tuberculosis are to be kept private.

Rule 5. School trustees and health authorities are required to regulate their quarantine in a certain way, as follows:

a. Absolute quarantine contemplates that no persons shall enter or leave the premises, guards being used to enforce this rule if necessary; the premises shall be placarded; no articles shall be allowed to pass out of the premises; food shall be furnished by the proper authorities under proper restrictions.

b. Modified quarantine contemplates that the same restrictions shall apply as in absolute quarantine, except that certain members of the family can enter and leave the premises if they take precautions; while the sick person is required to be isolated in a certain part of the premises.

c. Absolute isolation includes certain special measures of technical interest.

d. Modified isolation includes confinement of the patient and attendant in certain rooms, while the other members of the household are allowed to enter and leave as they please.

e. Special isolation includes prohibiting the patient from attending any public assemblage, providing separate sleeping apartments, and eating utensils, towels, and napkins for the patient.

f. Complete disinfection includes the disinfection during illness under direction of the physician of patient's body, of all excretions or discharges, of all clothing and utensils used by patient; after illness is over, the disinfection of walls, woodwork, furniture, bedding, etc.

g. Partial disinfection includes disinfection of discharges or excretions of patients and their clothing and the room occupied by patient during illness.

Rule 6. All disinfection required by these rules shall be done according to the method recommended by the Texas State Board of Health.

Rule 7. When he receives information to the effect that a contagious disease exists in his territory, the local health officer is required to placard the house with a flag or a card of a certain size and bearing the inscription "Contagious Disease."

Rule 8. After a house is placarded, and placed under quarantine, no person except those authorized to do so by the local health authority is allowed to enter or leave the premises or carry away from the premises any article by which the disease might be spread. This rule holds until the premises shall have been disinfected and released from quarantine.

Rule 9. When any person is exposed to a contagious disease, it is his duty to follow the instructions of the health officer, in order to avoid the spread of the disease.

Rule 10. No person affected with any contagious or quarantinable disease shall be allowed to ride in any public conveyance, or to be present in any public assemblage, or to travel any public thoroughfare.

Rule 11. It is unlawful for any person to remove or destroy the quarantine placard, and if it is removed, the owner of the premises

shall report this fact to the local health authority within twenty-four hours.

Rule 12. The following diseases are not only quarantinable, but are pestilential, and persons suffering from any of them are to be kept in absolute isolation, and the premises are to be absolutely quarantined as described in Rule 5, and complete disinfection must be performed after the termination of the illness: Asiatic cholera, plague, typhus fever, yellow fever.

Rule 13. The following diseases are dangerous contagious diseases, and persons suffering from any of them are to be placed in modified isolation, under modified quarantine, and complete disinfection must be performed after the termination of the illness: leprosy, smallpox, scarlet fever (scarlatina), diphtheria (membrabous croup) and dengue.

Rule 14. The following diseases are to be treated by special isolation and partial disinfection: typhoid fever, cerebro-spinal meningitis, epidemic dysentery, trachoma, tuberculosis, and anthrax.

Rule 15. The following diseases are quarantinable for school purposes, and persons suffering from these diseases are barred from school for twenty-one days: **Persons suffering from measles, whooping-cough, German measles (rotheln) and chicken-pox shall be required to be barred from school for twenty-one days (at the discretion of the local health officer) from date of onset of the disease, with such additional time as may be deemed necessary, and may be readmitted on a certificate by him attesting to their recovery and non-infectiousness.**

Rule 16. Minor diseases are to be excluded during illness. Those actually suffering from tonsillitis, itch (scabies), impetigo contagiosa, and favus shall be excluded from school during such illness and be readmitted on the certificate of the attending physician attesting to their recovery and non-infectiousness.

Rule 17. Additional precautionary measures may be instituted at the discretion of the local health authority.

Rule 18. When the local health officer hears of the existence of any contagious disease within the territory over which he has jurisdiction, it is his duty to investigate and if necessary declare a quarantine.

Rule 19. The local health officer is required to see that all quarantine in his territory is properly enforced, and that disinfection,

when required by law, is properly done. Persons exposed to smallpox, if unvaccinated, are required to be held for eighteen days from date of last exposure.

Rule 20. No person shall offer for rent any building in which a case of any quarantinable disease has occurred without previously having the building disinfected. This refers especially to houses which have been occupied by consumptives.

Rule 21. If disinfection is not performed as required, the house in which the contagious disease has occurred shall be placarded by the local health officer.

Rule 22. Nursese and midwives are required to report within twelve hours the presence of sore eyes or inflamed lids in the newly-born; this report is made to the local health officer or to any reputable physician.

Rule 23. When any quarantinable disease occurs, it shall be the duty of the householder in charge of the premises to report the presence of the disease to the local health officer. In the presence of a quarantinable disease, before quarantine is established, it is unlawful for any person to move out of the infected house, or to remove any articles from the house.

Rule 24. No person suffering with any reportable disease, or who resides in a house in which there exists a case of smallpox, scarlet fever, diphtheria, or typhoid fever, shall work or be permitted in or about any dairy or any establishment for the manufacture of food products, until the local health authority has given such a person a written certificate to the effect that no danger to the public will result from his or her employment or presence in such establishment.

Rule 25. When he is notified of the presence of smallpox or other quarantinable disease, the local health officer shall send immediately to the physician, or with his approval, to the patient, printed matter published by the State Board of Health relating to such cases.

Rule 26. Persons suffering from trachoma (granulated lids, contagious catarrhal conjunctivitis) are to be excluded from the schools unless they are under the strict supervision of a physician and hold a certificate from him to the effect that active inflammation has subsided; and this certificate must also be signed by the local health officer.

Rule 27. When any person suffering from smallpox, scarlet fever, or diphtheria is found to have been in a schoolroom, the school must be closed until the building has been properly disinfected under the supervision of the local health officer.

Rule 28. In the event that the disease causing the closing of school shall have been smallpox, the school must remain closed for eighteen days, unless the trustees require the vaccination of all unvaccinated pupils and teachers. In the latter case, the school may be reopened at once after disinfection.

Rule 29. The local health authority shall notify the superintendent or principal of any school of the locations of quarantinable diseases, and if the superintendent or principal finds any attendants in such schools who live in said houses, he shall deny them admission to the said schools, only admitting them again upon the presentation of a certificate from the attending physician, countersigned by the local health authority, that there is no danger from contagion.

Rule 30. No superintendent, principal, or teacher of any school, and no parent, master or guardian of any child or minor, having the power and authority to prevent, shall permit any such child or minor, having any quarantinable disease, or any child residing in any house in which any such disease exists or has recently existed, to attend any public, private, parochial, church or Sunday school until the requirements of these rules have been complied with.

Rule 31. In cities and incorporated towns, the city health authorities shall assume control of quarantine, isolation, and disinfection; in districts outside of cities and towns, the county health officer shall assume control.

Rule 32. Cities, counties, and towns have the privilege of declaring quarantines independently of the State Health Authorities, so long as the additional quarantine is consistent with and subordinate to the quarantines established by the Governor and State Board of Health. In case any local health authorities declare a quarantine, they are required to notify the State Board of Health.

Rule 33. All health authorities have the privilege of passing through quarantine lines provided they announce that they are acquainted with the disease they are visiting and will take precautions to prevent its spread.

VITAL STATISTICS.

Rule 34. Each birth occurring in Texas shall be reported by the physician, surgeon, or midwife, or in the absence of these, by the parent, to the city or county registrar.

Rule 35. Undertakers shall report each death to the local registrar, and the individual or firm selling the coffin is considered the undertaker.

Rule 36. All births and deaths, except those occurring in a city or incorporated town, shall be reported to the clerk of the county court; in cities and incorporated towns, births and deaths are reported to the city registrar.

Rule 37. Each city or incorporated town is a primary registration district. The city health officer shall be the local registrar. Each local registrar shall appoint a deputy to serve during his absence or disability, and both registrar and deputy are subject to the rules of this Code; provided, that in cities or towns where the secretary or other official is serving as local registrar, and where a burial or removal certificate is required before allowing any dead body to be buried within or removed from the city limits, such city secretary shall continue as the local registrar, but shall be subject to the regulations of this code. No body must be removed from or interred in any local registration district until the local registrar has issued a burial or removal certificate, and such certificate shall not be issued by the local registrar until he has received and filed the death certificate as described later; but a death or removal certificate issued in accordance with the law of the place the death occurred, whether in Texas or not, shall be sufficient authority for the local registrar to grant a burial permit; in this case, the local registrar shall write plainly across the face of the copy of the record which he sends in to the State Registrar the fact that the body was shipped in for burial. The city registrar is required to record in a permanently bound book all births and deaths, with the statistical data required by law, and at the end of each month, the city registrar shall forward to the State Registrar a copy of each birth or death certificate filed with him during the month.

Rule 38. All certificates of births and deaths shall be made according to the form prescribed by the State Board of Health.

Rule 39. For each dead body for which he provides a coffin, the undertaker shall fill out the death certificate, and shall turn the certificate over to the physician for the latter to give a signed statement as to the cause of death. The undertaker or physician shall then send the death certificate to the local registrar.

Rule 40. It is the physician's duty to be prompt in filling in the "medical particulars" of the death certificate.

Rule 41. In rural districts, where no undertaker officiates, the last attending physician shall hand in the death report.

Rule 42. Where a person dies without medical attendance, the coroner,, if one is called in, shall file the death report; if no coroner is called in, the householder on whose premises the death occurred shall report the death to the local health officer; the latter shall issue the death certificate, after holding an autopsy if necessary.

Rule 43. If a death occurs in a hospital, certain statistical facts are required to be given by the superintendent of the hospital before the undertaker sends in the report.

Rule 44. If any physician, coroner, or superintendent of any hospital refuses to fill in the medical particulars on the death report, the undertaker shall report this fact to the State Registrar for prosecution.

Rule 45. This relates to stillbirths, which shall be reported as both deaths and births.

Rule 46. The county clerk in each county shall preserve a bound record of all data contained in death and birth reports, and shall report monthly to the State Registrar of Vital Statistics.

Rule 47. Each sexton of a cemetery is required to file all burial permits received, and to send in a monthly report of all bodies interred to the State Registrar of Vital Statistics.

Rule 48. The State Registrar is required to have printed all death and birth certificates, while the city and county governments are required to have printed the permanently bound book for preserving birth and death records. The State Registrar has authority to require additional information about any birth or death from any person in possession of the facts.

Rule 49. The city and county registrars are required to furnish the birth and death certificate blanks to all persons using or requiring them.

Rule 50. The city or county registrar shall examine certificates

of birth and death to see that they are complete. He shall number the births and deaths in separate series, commencing anew at the beginning of each year.

DEPOTS, RAILWAY COACHES, AND SLEEPING CARS.

Rule 51. No person known to be suffering from smallpox, diphtheria, measles, scarlet fever, or whooping cough shall be allowed to enter or ride in any railway coach or street car, and in case any such person is discovered in such car, it shall be the duty of the conductor to notify the nearest local health officer who shall remove and isolate the patient as required by law.

Rule 52. All depots, railway coaches, interurban cars, and street cars must be properly ventilated and, in cold weather, heated.

Rule 53. Cuspidors in adequate numbers must be provided in all depots and waiting rooms, as well as in railway coaches; these cuspidors must contain at least one-third pint each of some approved disinfectant solution, and must be cleaned out every twenty-four hours.

Rule 54. Dry dusting and sweeping is prohibited at all times in waiting rooms of depots and railway stations, and in railway coaches, interrurban cars, and street cars.

Rule 55. Railway day coaches shall be thoroughly cleaned according to the method prescribed by law at the end of each trip, or at least as often as once in forty-eight hours, when in use.

Rule 56. Railway waiting rooms shall also be cleaned in a sanitary manner once in each twenty-four hours.

Rule 57. Parlor, buffet, and dining cars must be thoroughly cleaned at each terminal; food-boxes, refrigerators, closets, drawers, and cupboards must be cleansed, scalded, and disinfected with an approved disinfectant.

Rule 58. Interurban and street cars must be washed with a hose and scrubbed thoroughly once every twenty-four hours, and must be fumigated immediately after any case of contagious disease has been discovered therein.

Rule 59. Sleeping cars must be cleansed thoroughly and disinfected at least twice in each week, except that on certain lines designated by the President of the State Board of Health, one cleansing and one disinfection per week may suffice; these cars

must always be disinfected, however, immediately after any one suffering from any contagious or infectious disease is discovered therein.

Rule 60. In each passenger car operated in Texas, a signed record must be kept showing the place and date of each disinfection, the length of time devoted to such disinfection, and the name of the person doing the disinfecting.

Rule 61. All depots, railway coaches, interurban cars, and sleeping cars must be provided with a water cooler for the use of patrons; these coolers must be kept sanitary, must be cleansed once in each twenty-four hours, and the ice used therein must be handled with tongs, and not dumped on floors, sidewalks, or car platforms.

Rule 62. Expectorating or spitting on the floors, walls, or furniture of any depot, waiting room, platform, or any street car. railway coach, or interurban car is prohibited, and placards must be displayed calling the attention of the public to this fact.

Rule 63. Brushing of teeth or expectorating in basins used for lavatory purposes is prohibited, and placards announcing this fact shall be hung in proper places.

Rule 64. Sleeping car companies shall provide separate compartments for their negro porters.

Rule 65. Negro porters shall not sleep in sleeping car berths nor use bedding intended for white passengers.

Rule 66. No waiting room in any railway station or depot shall be floored in part or entirely with burlap or coca matting.

Rule 67. All depots and railway stations shall be provided with water closets which shall be so constructed as to exclude flies; these water closets shall be kept in sanitary condition, and shall be cleaned, emptied, and disinfected at least once in each thirty days.

Rule 68. The premises of all railway stations shall be thoroughly drained, so that no stagnant water shall collect thereon.

Rule 69. All cisterns, fire-water barrels, or other water containers upon the premises of any depot or railway station shall be screened with not less than 16-mesh wire gauze.

NOTE:—The rules governing the transportation of dead bodies are omitted. They are of technical interest and can be obtained from any railway or express agent.

APPENDIX C.

Poisoning.

When a person has taken poison, there are certain general rules to follow, whether the nature of the poison be known or not. These general rules are given below, together with special reference to the commoner poisons.

If the patient seems faint, let him lie down; then give him stimulants, such as a cup or two of strong coffee, a teaspoonful of aromatic spirits of ammonia, a teaspoonful of Hoffman's anodyne, or a drink of whiskey.

If a patient seems sleepy, keep him awake by bathing his face with cold water and fanning him; but do not wear him out by walking him around.

If the extremities are cold, warm them with hot water bottles or warm bricks or stove-eyes.

To produce vomiting, a tablespoonful of mustard in a pint of warm water is immediately effective. Warm, salty water in large amounts is also good. The stomach tube is good in the hands of a physician or nurse.

If an acid has been swallowed (carbolic acid is not here included) alkaline substances should be given, such as cooking soda, prepared chalk, whiting, magnesia, limewater. Follow with raw eggs or olive oil.

If a strong alkali has been taken, such a concentrated lye, acids like vinegar or lemon juice, should be given. Follow with raw eggs or olive oil.

Carbolic acid poisoning must be treated within twenty minutes or death may result. The treatment is undiluted whiskey, or pure grain alcohol diluted half and half with water. If this is not at hand, epsom salts in the usual doses is almost as good. If the alcohol is used, epsom salts should be used a little later.

Poisoning from rough on rats or other forms of arsenic should be treated by remedies to cause vomiting as described above. These

should be followed or accompanied by raw eggs or cooked starch paste. The druggists prepare a regular antidote to arsenic, which should be given as soon as it can be obtained.

Fig. 265. Medicines and poisons should be locked up out of the reach of children.

Phosphorous poisoning should be treated by remedies to cause vomiting, and by stimulants and raw eggs. No oil should be given under any circumstances.

Morphine, paregoric, laudanum and other forms of opium all act alike, and should be treated by remedies which cause vomiting, by tannic acid, one teaspoonful, or by potassium permanganate, five grains, repeated in ten minutes. In addition, the patient should be kept awake by strong coffee, cold water, and attempts at rousing.

To avoid poisoning, the medicines and poisons should be kept out of the reach of children, and should never be given in the dark. When concentrated lye is used in scrubbing the floor, the open can should never be left on the floor or in reach of children.

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